EXPERIENCE USING A SMALL FIELD OF VIEW GAMMA CAMERA FOR INTRAOPERATIVE SENTINEL LYMPH NODE PROCEDURES

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EXPERIENCE USING A SMALL FIELD OF VIEW GAMMA CAMERA FOR INTRAOPERATIVE SENTINEL LYMPH NODE PROCEDURES

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LIST OF ABBREVIATIONS AND SYMBOLS

AJCC	Americaon Joint Committee on Cancer
CdTe	cadmium telluride
CdZnTe	cadmium zinc telluride
CPD	camera/probe/dye
CsI(Tl)	cesium iodide doped with thallium
ELND	elective lymph node dissection
FALD	full axillary lymph dissection
FOV	field of view
GA Tech	Georgia Institute of Technology
GM	Geiger-Mueller
H&E	hematoxylin and eosin
IHC	immunohistochemical
NaI(Tl)	sodium iodide doped with thallium
PD	probe/dye
PSPMT	position-sensitive photomultiplier tube
SLN	sentinel lymph node
Tc-99m	technetium-99 metastable
VAMC—Atlanta	Veterans Affair Medical Center—Atlanta

SUMMARY

Staging is critical in the management of cancer. Sentinel lymph node (SLN) biopsy is one method used in the assessment of cancer spread. SLN procedures are standard practice in the management of some cancers although; these procedures have only recently been developed and refined. SLN procedures are commonly used in the management of melanomas and breast cancers in patients with no evidence of metastatic disease on clinical exam.

SLN procedures include detection, localization, and assessment of SLNs. The detection/localization components vary in technique and rates of success. The procedures with the least number of detection/localization techniques generally include the use of blue dye or the use of a radiotracer with intraoperative gamma counting. The most complex procedures involve the use of blue dye, the use of a radiotracer with preoperative gamma imaging and preoperative gamma counting, intraoperative gamma counting, or some combination of these techniques.

The ideal procedure for SLN would include all the listed techniques however; all facilities do not incorporate the most complete procedure, for different reasons. An investigation using a small FOV (5 in x 5 in) gamma camera intraoperatively for SLN procedures in melanoma and breast cancer patients was performed. A smaller FOV camera is capable of obtaining some of the same information as a conventional gamma camera. It is possible that centers, which do not or are not able to take advantage of

preoperative imaging, may find the use of a smaller FOV gamma camera in the operating room useful.

The investigation consisted of a total of 41 patients; it was split into two studies, Study 1: melanoma and study 2: breast cancer. The melanoma study found the added use of a smaller FOV camera under the parameters of this study to be minimal. Study 2 was broken into two branches; branch 1: camera/probe/dye and branch 2: probe/dye, for a comparison study. Comparing the two branches did not show the smaller FOV camera to reduce the time spent in the operating room versus using the probe and blue dye.

CHAPTER 1: INTRODUCTION

Staging of disease is an important factor in determining a cancer patient's management and prognosis. One component of staging melanoma and breast cancer is assessment of the lymph nodes local and regional to disease. Historically, assessment has involved resection and histological evaluation of a significant number of nodes; excision and evaluation of 10 to 30 nodes is not uncommon. Elective regional lymph node dissection (ELND), extensive removal of local and regional nodes near a melanoma, and full axillary lymph node dissection (FALD), removal of most axillary nodes near breast cancer, have been components of standard-of-care management of melanoma and breast cancer patients, respectively. Such resections and analyses are useful for some patients, but for many patients, particularly those with no pre-surgical clinical indications of metastases, such procedures often result in added morbidity without added survival benefit.

Sentinel lymph node (SLN) biopsy is an alternative to a radical lymph node resection for lymphatic assessments. In a SLN biopsy procedure, only one or a few key nodes, referred to as SLNs, are excised. The premise behind SLN procedures is metastasis of cancer is systematic. That is, cancer spread is first local, then regional, then distant. With this assumption a negative examination of locally assessed nodes would make an investigation of regional or distant spread unnecessary. By locating and assessing SLNs, the nodes nearest a cancer, a SLN procedure limits or eliminates additional investigations, if the SLNs contain no evidence of metastasis then. Toward the goal of

high confidence as regards the absence of metastasis in SLNs, SLN procedures include a more extensive histological evaluation of nodes considered SLNs. The limited number nodes excised in SLN procedures are generally evaluated much more extensively than the numerous nodes excised in ELNDs and FALDs.

Currently, there are several forms of SLN procedures; most forms are similar in that they involve the same fundamental techniques. However, the rates of success of the various procedures vary greatly; in fact, the success rates of some vary greatly when simply conducted by different practitioners. The least complex of existing SLN procedures, as regards number of techniques involved, includes those that use intraoperative visualization of blue dye or those that use intraoperative detection of a radiotracer with a gamma counting probe. In blue-dye only procedures, the dye diffuses from near a cancer into the lymphatic system and into nodes; In radiotracer only procedures, the radiotracer diffuses from near a cancer into the lymphatic system and into the nodes.

More complex procedures are those that use both techniques and those that include preoperative imaging with a gamma camera. A procedure is considered successful if SLNs are identified, removed, and assessed. Preoperative imaging is an important component of the SLN procedure in which radioactivity is used; however, it is not performed or not performed well at some institutions. Adding intraoperative imaging to the SLN procedure could be beneficial to many institutions. It is possible for intraoperative imaging to provide much of the information that some preoperative imaging provides and it could be more practical at some institutions

The most inclusive method with preoperative imaging would be recommended for any center performing SLN biopsies; there is no substitute for preoperative imaging performed by a skilled nuclear medicine technologist. Intraoperative imaging with a relatively small FOV gamma camera should not be used to replace preoperative imaging or the intraoperative use of a gamma probe but, should be used concurrently with these procedures. The benefits of using a small field-of-view camera during SLN procedures for breast cancer and melanoma are unknown at this time.

A clinical evaluation was performed to investigate the added benefit of adding a small FOV gamma camera to SLN biopsies and investigating the operating procedures after adding the small FOV camera to surgery. The investigation was split into two different studies: Study 1 melanoma and study 2 breast cancer. Study 2 was defined into a more explicit study containing branch 1and branch 2. Each investigation consisted of a skilled surgeon, skilled nuclear medicine technologist, experienced scientist and a gamma camera with a 5 in x 5 in FOV GammaCam (Gamma Medica, Northridge, CA).

The outcome of the studies was specific to the details of each study. The details of each study make it possible for future investigations of a relatively small FOV camera used intraoperatively for SLN procedures. Changing the variables such as the type of cancer, the skill level of the surgeon and other details may result in very different outcome for the value of such a camera. The details of each study and much more are explained throughout this paper.

The layout of this paper is as follows:

Chapter 2 gives background information about the diseases melanoma and breast cancer. This chapter lays out general information which may help understand the idea behind sentinel lymph node dissection however, this chapter is not critical to understanding SLNs or gamma cameras.

Chapter 3 provides detailed information on SLN biopsies. This chapter explains the concept and how it the procedure is performed as well as giving the history of SLN procedures.

Chapter 4 explains gamma detection devices, the history of the devices and how they are used in regards to SLN biopsies.

Chapter 5 gives explicit details about the methods used for this investigation as well as listing the specific devices used. The chapter divides the methods by each of the two studies in this investigation.

Chapter 6 presents the results observed in this investigation. The results are presented separately for each study in the investigation.

Chapter 7 is the discussion about the results observed in the investigation. This chapter gives possible explanations for the results of this investigation. The discussion chapter is divided into the two studies.

Chapter 8 is the final chapter of this document; it has the conclusions, observations and future directions. The conclusion gives a summary of the entire investigation and its significance. The observation section of this chapter reveals some anecdotal information on small FOV gamma cameras. The chapter ends with possible future investigations to further the research involving intraoperative gamma cameras and SLN procedures.

CHAPTER 2: MELANOMA AND BREAST CANCER

2.1 Melanoma

2.1.1. Melanoma Types

In 1787, John Hunter reported the first documented case of cutaneous melanoma [Balch 85]. He did not call his findings melanoma, but he was the first to describe a form of the disease we now call melanoma. In 1907, William Handley described the first reasonable surgical approach for the management of metastatic melanoma. In his report, which was based on a single autopsy, he suggested removal of obvious disease, removal of two inches of subcutaneaous tissue, and the performance of a radical local regional lymph node resection. His guidelines for the management of melanoma were followed for 50 years [Balch 85, Eady 03]. Most of the guidelines are still part of standard care. What is no longer considered standard of care in all cases is performance of a radical local regional lymph node resection.

Fifty percent or more of all cancers are skin cancers. Melanoma accounts for only about four percent of all skin cancers; however, it is the cause of seventy-nine percent of all deaths due to skin cancer [Statius 99]. Melanoma is a more serious skin cancer than most, because it can readily spread through the lymph channels and blood to infect other parts of the body [Statius 99]. Melanoma develops in melanocytes, pigment cells that lie beneath the outermost layer of epidermis but above the dermis layer. Melanoma can occur most anywhere on the skin; it can also occur in the eye and in relatively rare instances in the membranes of the nasal passages, oral, pharayngeal mucosa, and vaginal and anal mucosa.

Detection of melanoma starts with here are common signs and symptoms to look for in detecting melanoma. The primary features to look for when detecting/looking for melanoma is change, a change in the skin lesion, mole, or freckle [Balch 85]. A mole on the skin is usually round and seems to be evenly colored. Moles may appear during a person's lifetime or they are present from birth. Usually the first sign of a problem is when a mole or lesion begins to change. A heuristic method of detecting change is the ABCD rule. The rule notes general characteristics to consistently observe. First look for asymmetry in the lesions: when half of lesion seems to be apparently different, there is crust raising, or the surface begins to crust. Secondly pay attention to the borders of the lesion. Look for indentations or notches around the border. Next observe color, normally a lesion will start to become dark or appear patchy. The D represents the diameter of the lesion. If the lesion begins to grow the diameter will increase [Zalaudak 03].There are many other symptoms to be aware of such as itching, bleeding, ulcerations, swollen lymph nodes and more. However observing the most common symptoms can often help lead to early detection.

Cutaneous melanoma is the most common type of melanoma. An estimated 55,000 Americans will be diagnosed with cutaneous melanoma; fourteen percent of whom will die of the disease [Tsao 04]. There are four different types of cutaneous melanoma; they are characterized by their growth patterns [Balch 85].

The Clark melanocytic nevus, more commonly referred to as superficial spreading melanoma (SSM) accounts for approximately seventy percent of melanomas. SSM is the most common cutaneous melanoma, it normally originates in a preexisting nevus. It is less aggressive because it has two growth stages; it spreads in a radial direction through the epidermis before maturing, cloning and spreading depth-wise into the dermis. The more aggressive nodular melanoma (NM) accounts for fifteen to thirty percent of melanomas. NM is the most aggressive and has the shortest clinical onset of the four types of melanoma Nodular melanoma is more aggressive because there is no radial phase; At the time of diagnosis NM has often reached the fully invasive stage because it immediately begins to grow depth-wise directly into the dermis layer of the skin making it harder to cure . Lentigo melana (LM), also known as Lentigonous malignant melanoma, makes up less than ten percent of melanomas. LM spreads at a slow rate along the surface of the skin; it has a varied benign stage anywhere between five to fifteen years. Acrolentiginous melanoma (ACM) makes up a smaller percentage than Lentigo melana. ACM unlike SSM and NM is more common to Asians and African Americans than Caucasians and it is normally located on the palms of the hands, nail bed, and soles of the feet. ACM makes up four to eight percent of cutaneous melanoma but it accounts for thirty-five to sixty percent of melanoma cases found in minorities. ACM is named for its arrangement of the melanocytes in a single file or “lentiginous” pattern.

2.1.2 Staging

Staging in melanoma and all other cancers is the process of assessing and designating extent and progression of disease. For the staging of melanoma, a four-stage system,

outlined in Table 2.1, was developed in the late 1970's at the M. D. Anderson Cancer Center at the University of Texas [Gershenwald 98].

Table 2.1 The four-stage system for staging melanoma.

Stage I	Includes patients with primary melanoma only
Stage II	Includes patients with local recurrence (within 3cm of primary)
Stage III	Includes patients with regional disease
IIIA	Intransit metastases
IIIA	Nodal metastases
IIIAB	Intransit plus nodal metastases
Stage IV	Includes patients with distant disease
IVA	Cutaneous only
IVB	Any visceral site

The flaw of this four staging system is that it did not include microstaging patients with primary melanoma, which is the largest patient group [Gershenwald 98]. Microstaging is an integral part of the prognosis of melanoma; it is based on the microscopic examination of the primary lesion; presented in 1962 by Petersen et al. [Gershenwald 98]. There are two methods that are used for characterizing microstaging in localized melanoma, the Clark level and Breslow thickness, the two methods together are part of the new tumor-node-metastasis (TNM) staging system adopted by the American Joint Committee on Cancer (AJCC) [Eady 03, Zalaudak 03, AJCC]. A report was published in 1985 by Clark et al stating melanomas can develop in a stage specific manor [Kirkwood 98]. The Clark level developed by Clark et al in 1969, is based on the level of invasion, the local extension within the primary site, whereas the Breslow thickness developed in 1970, is a measure of tumor volume, how deep the tumor has extended from the granular layer to

the point of deepest penetration. The tumor has to be bisected in order for microstaging to occur. Once the primary lesion is removed pathology examines the lesion. Breslow thickness is measured in millimeters and predicts a statistical likelihood of a 5-year chance of survival (Table 2.2). The Clark's level is not measured in millimeters but is described by level of invasion in the layers of the skin (Table 2.3). Clinical staging is also important, it is a noninvasive technique. Clinical staging consists of a complete doctor's examination including; palpation of the lymph nodes for drainage, liver and spleen; a complete medical history, a complete examination of the skin and a blood test and chest x-ray (if patient is found to be in stage I). As the melanoma grows deeper into the skin it has the ability to move from the primary sites by either entering the bloodstream or the lymphatic system. After the melanoma has penetrated the lymph vessels within the layers of skin it travels through the fluid to the lymph nodes. The depth of the melanoma and the extent of nodal metastasis are key factors for determining the prognosis in melanoma [Gershenwald 98, Kim 02].

Table 2.2 Breslow system for the micro staging of melanoma

Thickness in millimeters/inches	5-year survival rate
≤ 0.75 mm(≈ 1/32 inch)	96%
0.76-1.49 mm(≈ 1/32 to 1/16 inch)	87%
1.5-2.49 mm (≈ 1/16 to 1/11 inch)	75%
2.50-3.99 mm(≈ 1/11 to 1/8 inch)	66%
≥ 4.0 mm(≈ 1/8 inch)	47%

Table 2.3 Clark staging by level involvement

Stage I	Tumor cells confined to the dermis layer
Stage II	Tumor cells penetrate into the papillary dermis
Stage III	Tumor cells completely fill the papillary dermis
Stage IV	Tumor cells enter the reticular dermis
Stage V	Tumor cells fill the dermis and enter the subcutaneous fat

(According to the AJCC recommendations of combined staging of clinical and micro staging, lymph node involvement is to be designated stage II.)

2.2 Breast Cancer

2.2.1 Staging of Breast Cancer

According to the National Cancer Institute breast cancer is the most common non-skin cancer and second to lung cancer as the leading cause of cancer related deaths in women today [ACS 03]. Evidence of the earliest cases of breast cancer is found in the Smith papyrus that dates back to the early Egyptians in 1600B.C. Although not called cancer, treatment of the ulcers or tumors included cauterization by a tool called “fire drill”. A major breakthrough in understanding cancer was made by Dr Henri Francois LeDran (1685-1770); he recognized that breast cancer could and did spread to the axillary lymph nodes; he was the first to associate a poor prognosis with lymph involvement. Much of the therapy and treatment today is based on his findings. In the mid 1800’s when surgeons began to keep detailed records, it was shown that women treated with mastectomy had a high rate of recurrence within an eight year period. Over the last decade, the prognosis for breast cancer patients has improved, even more so for patients under the age of 50. The mortality rates have decreased by 2.3% per year from 1991 to 2000 for all women diagnosed with breast cancer and 3.7% for women under the age of 50 [ACS 03].

The breast is made up of: fatty tissue, connective tissue between the fat and skin (Cooper's ligament), 15-20 lobes, ducts that are connected to each lobe, a nipple and areaolas [Cook 96, Marchant 97]. The lobes contain alveoli, where milk is produced during lactation; the milk travels from the alveoli into the ducts and out of the nipple. The ducts resemble tree branches, the few collecting ducts in the nipple branch and end in terminal ductal lobular units. Blood vessels and lymphatic vessels are also located in the breast; the lymphatic vessels arise in the periductal spaces and drain to the axillary nodes [Marchant 97, Cook 96].

The most common types of breast cancer are ductal carcinoma and lobular carcinoma. Carcinoma is a cancer that develops in the epithelial tissues of the body. Invasive ductal carcinoma (IDC) spreads through the duct walls and invades the outside tissue; IDC develops from ductal carcinoma *in situ*, which develops in the milk ducts of the breast. DCIS is almost always curable since it is confined to the milk ducts Invasive lobular carcinoma (ILC) begins in the epithelial cell of the lobes, the milk glands of the breast [Cook 96]. Lobular carcinoma *in situ* is a noninfiltrating cancer; however, it is a marker for increased risk of developing breast cancer later.

Early detection is one of the best ways to help fight against breast cancer. Women should visit their doctors regularly; between regular visits women can also perform monthly self-breast exams. In addition to the self-breast exams women should be aware of some common symptoms: a lump on or near the breast or in the underarm area; a change in the

size or shape of the breast; a discharge in the nipple; or a change in the color or feel in the skin of the breast areola, or nipple [Cook 96].

2.2.2 Staging

Staging for breast cancer and other solid tumors is based on the anatomical "TNM" system [Lohr 90]. This system classifies the tumor and local extent of tumor (T), the degree of nodal involvement (N), and absence or presence of metastasis (M) [Lohr 90, Marchant 97]. There are four basic stages (table 2.4) of breast cancer and the four stages are broken according to the TNM classification (table 2.5).

Table 2.4 AJCC staging for breast cancer

Stage	**Definition**
I	Tumor <2 cm
II	Tumor 2-5 cm, Nodes 1-3 metastasis
III	Tumor >5, Nodes 4-9 lymph, apparent mammary nodes
IV	Tumor any size, Nodes any #, Metastasis to other organs

Table 2.5 The AJCC TNM staging for breast cancer

"T" Primary Tumor	
TX	Primary tumor can not be assessed
Tis	Carcinoma *in situ*
T0	No evidence of primary tumor
T1	Tumor is 2cm in greatest dimension
T2	Tumor is >2 cm and < 5 cm
T3	Tumor is> 5cm
T4	Tumor is any size with direct extension to chest wall or skin
"N" Regional lymph nodes	
NX	Regional lymph nodes can not be assessed
N0	No regional lymph node metastasis
N1	Metastasis to 1-3 axillary nodes or mammary with microscopic disease
N1mi	Micrometastasis >0.2 mm, ≤ 2.0 mm
N2	Metastasis to 4-9 axillary nodes or apparent internal mammary nodes
N3	Metastasis in 10+ axillary nodes
"M" Distant metastasis	
MX	Can not be assessed
MO	No distant metastasis
M1	Distant metastasis

Staging is part of the Diagnosis of cancer. The AJCC staging system is reviewed every few years. Staging for breast cancer determines if the cancer has metastasized, progressed into or past the lymph nodes. Metastatic disease is present in 5% or women at the initial diagnosis [winner, ellis]. In 2004 approximately 41,000 women died from metastatic breast cancer [winner, ellis]. Staging the cancer once it is confirmed will allow the doctor and patient to better plan a course for treatment.

CHAPTER 3: SENTINEL LYMPH NODE BIOPSY

3.1 Sentinel Lymph Nodes

As indicated above, accurate staging of disease in a melanoma or breast cancer patient is critical for determination of accurate prognosis and of appropriate management of the patient's disease. A significant component of the staging of melanoma and of the staging of breast cancer is determination of the extent of lymph node involvement—absence or presence of nodal involvement and number, location and extent of disease of involved lymph nodes. In patients with clinical evidence of nodal involvement, local regional node resection is often a component of staging. Such procedures usually result in the excision of multiple nodes and "routine" histological assessment of the excised nodes. In patients without clinical evidence of nodal involvement, such radical surgery seems to be unnecessary. Alternatives to radical resection biopsies are procedures known as sentinel lymph node (SLN) biopsies. Such are limited nodal resections in which only one to a few nodes are excised and assessed rather than the multiple nodes excised and assessed in radical resections. SLN biopsies are generally also procedures in which assessment of each excised node is much more extensive than it is in procedures involving

The revised AJCC staging system is based on the fundamental idea that each melanoma, breast cancer or other neoplastic disease spreads systematically, beginning with an increase in the size of the neoplasm, and followed by local invasion and local nodal metastasis and finally transport by the circulatory and lymphatic systems to other organs and tissue [Kim 02]. For most cancers, a key prognostic factor is the number of lymph nodes with metastatic disease. Prior to the work of Morton et al.[Morton 92], assessment

of the status of lymph nodes was treated various ways from an elective lymph node dissection, to a wait and see approach [Statius 01]. There are two types of lymph node dissections, therapeutic lymph dissection and an elective lymph node dissection (ELND). In a therapeutic lymph node dissection once the lymph nodes are palpable or a biopsy is found to be positive, either by surgery or needle aspiration, the nodes are removed to alleviate pain and try to prevent spread. Therapeutic lymph dissection is management and care but an ELND is a preventative and prognostic measure. An ELND, FALD or a complete regional lymph node dissection removes a large number of lymph nodes from a certain area. Not all patients qualify to have this done, patients who do not have palpable nodes, and patients whose disease is thought to proceed to regional lymph nodes [Kenet 98]. The morbidity resulting from ELND is the greatest drawback. The morbidity may consist of swelling, water retention, pain and/or lymphodema. The debate centered around ELND is, after having the surgery and accepting the great risk, there is no guarantee for benefits of survival [Tanis 01]. An alternative method to ELND which would not involve the associated morbidity is based on the systematic pattern idea, Sentinel lymph node resection (SLN)

3.2 History to Present

Morton et al. were the first to use a SLN technique for melanoma [Balch 85, Keshtgar 99, Nieweg 99, Zanzonico 00, Britten 99, Tsao 04]. The lymphatic system is a subsystem of the circulatory system. It has three functions it defends the body against foreign bodies such as viruses, bacteria or fungi by the flow of lymph (a bodily fluid) which circulates through lymphatic capillaries in the body collecting waste to deposit and filter out in the larger lymph nodes and it absorbs lipids from the intestine and carries them to the blood.

Lymph nodes are found through out the body: in the abdominal and chest cavities, in the neck, the limbs and where the limbs join the trunk of the body. The major groups of lymph nodes, the nodes of importance in melanoma and breast biopsies, lie in certain areas of the body: mastoid and sub occipital nodes of the head, cervical lymph nodes of the neck, axillary lymph nodes under the arms, inguinal lymph nodes of the groin area, and popliteal noded behind the knee. The sentinel lymph node is defined as the first lymph node to receive drainage from the primary tumor. Therefore, ideally if the tumor has metastasized to the lymph nodes they would be found in the sentinel nodes otherwise it has not yet metastasized and there is not a need for a full lymph node dissection. One of the first groups, Cabanas et al, to map the sentinel node using lymphangiography reported on the sentinel node in 1977 in a series of penile cancer surgical management cases [Alazraki 00]. SLN resection is used with many other types of cancers including breast, head and neck, and penile. Cabanas did not make use of current intraoperative techniques he simply used anatomical knowledge about lymph nodes and his preoperative lymphatic maping to intraoperatively palpate along the anticipated course of lymphatic drainage from the primary site to the first lymph node [Tanis 01, Alazraki 00]. This first node that he encountered he labeled, the SLN. Morton et al used more than just anatomical knowledge during surgery they made use of isosulphan blue dye. The concept of blue dye is that it flows through the lymphatic channels and stains the channels and lymph nodes. It is assumed that all sentinel nodes have been stained blue, therefore surgeons have to remove all the blue nodes to attain the SLNs. Radiotracers were first used in SLN localization by Krag et al in 1993 for melanoma surgeries [Knoll 89]. They used a technetium-99m (Tc-99m) labeled sulfur colloid particle and it was injected into the

patient prior to surgery and a hand-held gamma probe was used during surgery to detect the radiotracer. Currently blue dye, gamma probes, radioactive tracer and lymphoscintigraphy are used intraoperatively or preoperatively to assist SLN resection. SLN and these methods are used with other types of cancers. Twenty years prior to Cabanas reporting lymphatic drainage to the sentinel node from the penis, Gould performed a radical neck dissection a decision guided by a pathology report finding metastatic tumor in lymph node, suggesting a pattern for metastases [Baur-Subareoler, Tanis 01]. In the late 1970's lymphoscintigraphy was used for the management in breast cancer patients although these were not SLN procedures. It wasn't until the early 90's that the SLN concept was applied to the management of breast cancer patients. Today SLN localization has been performed in colorectal cancers, gastrointestinal cancers, cervical, prostate cancers, head and neck, breast cancers and melanoma.

3.3 General Technique

Localization of SLNs is a component of standard practice in the management of most melanoma patients and many breast cancer patients with no clinical evidence of metastatic disease. Localization protocols vary in complexity and success. Those with the least components involve only intraoperative visualization of blue dye. At present, protocols with the most complexity involve preoperative radiotracer imaging, intraoperative gamma counting and intraoperative blue dye visualization. These protocols are more complex because there are more components and people to involve not because there is a higher level of difficulty or risk associated with the procedure. On the contrary,

the more complex procedure provides a smaller amount of risk and a higher level of success; success meaning the sentinel nodes were found and removed for pathology.

3.3.1 Preoperative imaging

Lymphoscintigraphy, the preoperative imaging was developed in the late 1950's. It is performed by a nuclear medicine technologist. Preoperative imaging is important in melanoma because there are many drainage pathways from a tumor site and many times there is lymphatic drainage that is unexpected [Uren 03]. A radiotracer, Tc-99m sulfur colloid, is injected into the patient approximately five minutes before imaging begins. The ideal radiotracer in the United States the Tc-99m sulfur colloid is the only approved commercial product used for sentinel lymph node related lymphoscintigraphy and intraoperative probe guidance [Aarsvold 05]. The radiocolloid is made in two forms filtered and unfiltered. Filtered colloid particles use .22 µm filtration resulting in an injectate with particles that are smaller than 220 millimicra. Most particles are between 100 millimicra and 220 millimicra. A comparative study of other colloids used in lymphoscintigraphy found that when colloids of sizes .220 µm to .100 µm were used the highest counts were recovered in the sentinel lymph nodes [Edreir 01]. Unfiltered Tc-99m sulfur colloid has a wide range of particle sizes with an average of approximately 305-340 millimicra and the largest is approximately 1000 millimicra. Sentinel node visualization using the different forms of radiocolloid was shown to be similar in a comparison study; although the visualization of lymphatic channels leading to the sentinel nodes was shown to occur more often when a filtered colloid is used [Goldfarb 98].

The radiotracer is administered by a subdermal or intradermal injection, which is an injection made right below the first layers of skin for melanoma and peritumoral, subdermal, or periareolar for breast cancer [Maza 03, Uren 03, Aarsvold 05]. The radiotracer is given at four to eight points around the tumor site. The activity and volume depends on the surgical team. The technologist massages the injection area to help disperse the radiotracer throughout the body. This procedure can take 30minutes to an hour but generally no longer than two hours. Dynamic images are acquired first, these allow the technologist to record the flow of radiotracer; and then static images are acquired. A large cobalt-57 flood source is used for transmission images to give the images a body outline for anatomical reference points. Before the technologist completes imaging, a mark is made on the body to reference the sentinel node(s).

3.3.2 Intraoprative Imaging

After the preoperative imaging is complete the patient is ready for surgery. The time of preoperative imaging to surgery depends on the relationship between the surgical and the nuclear medicine staff. The preoperative images can be done an hour prior to surgery or twenty-four hours prior to surgery although the surgery is usually on the same day as preoperative imaging, it is more convenient for the patient. The patient is prepped for surgery and put to sleep. After the patient is put to sleep the surgeon injects isosulfan blue dye. The blue dye is injected intradermally or subdermally [Aarsvold 05]. The surgeon then uses the surgical gamma probe and the mark made by the technologist to find the area to make the incision. The surgical gamma probe system used in surgery depends on the surgeon. There are many systems to choose from and the surgeon preference might be based on the tone and volume of the audio signal or the display for the counts or the ease

of use during surgery. The surgeon makes the incision and removes the blue and hot nodes found; sometimes they are just blue, sometimes they are just hot, sometimes they are secondary nodes and sometimes they are blue and hot. Once the nodes are removed they are sent to pathology.

3.3.3 Pathology

SLN resection has affected pathology in a positive way. Prior to SLN resections ten to thirty nodes were sent to pathology for examination; with SLN procedures there are usually one to three nodes and less commonly four sent to pathology. A more thorough examination can be done on a considerably smaller number of nodes. A histopathologic examination performed by pathologist includes mulisectioning and multiple analyses of the nodes. The multisectioning rather than bisecting of the nodes results much more tissue, 2 to 4 times as much, being examined increasing the detection of metastatic disease. An imunnohistochemical (IHC) analysis is also performed on the nodes that are sent to pathology, which also increases metastatic tumor detection compared with H&E staining. In breast cancer IHC analysis increase the percentage of micrometasis found in lymph node by an average of 20%, depending on the type of cancer [van Diest 99].

After the nodes are removed and sent to pathology the surgeon has completed the SLN resection. If results confirm there are positive nodes the surgeon may follow-up with a complete regional lymphadenectomy and chemotherapy [Statius 01]. The follow-up treatment depends on many other factors about the case as well as the results of the SLN resection although it usually involves examinations at 3-6 month intervals. .

CHAPTER 4: GAMMA DETECTION AND IMAGING

4.1 Gamma Detection in Sentinel Lymph Node Biopsies

Two nuclear medicine techniques are used extensively in SLN biopsy procedures. These are gamma imaging and gamma counting. In most cases, what are detected are emissions of a Tc-99m labeled colloid, such as sulfur colloid. The techniques are tools for the detection and localization of possible SLNs. In some standard protocols preoperative gamma imaging is performed, in some preoperative gamma counting, in others intraoperative gamma counting, and in still others combinations of these techniques. Nuclear medicine techniques are not used in all SLN biopsy procedures; some practitioners use mostly visualization of blue dye. However, nuclear medicine techniques are used in the majority of SLN procedures. The focus of this thesis is intraoperative gamma imaging, specifically intraoperative gamma imaging with a novel relatively small FOV gamma camera. In this chapter, as foundation for understanding the technologies at play, we review briefly the conventional nuclear medicine technologies used in SLN biopsy procedures. We begin with a discussion of conventional gamma cameras and gamma counting probes and end the chapter with novel small and relatively small FOV gamma cameras.

4.2 Conventional Gamma Cameras

Gamma imaging is performed in SLN biopsy protocols as a means of detecting and locating possible SLNs. A radiopharmaceutical, such as Tc-99m labeled sulfur colloid, is injected near a melanoma or breast cancer

When preoperative lymphoscintigraphy is performed in SLN biopsy procedures, it is done so to observe and record lymphatic flow, more specifically, lymphatic flow from near the primary tumor to nodes considered possible SLNs. In most procedures, a Tc-99m labeled colloid is injected into the patient and the imaging is performed using a large FOV gamma camera. An additional source is often used as a contrast source in order to obtain an anatomical outline for a point of reference. The gamma camera is based on the original design of 1958 by Hal Anger [Keshtgar 99, Knoll 89]. A single headed planar gamma camera is used for the preoperative imaging for SLN localization. The camera head is made of a lead collimator, a scintillation crystal and position-sensitive photo multiplier tubes (PSPMT). The gamma camera works by sensing two-dimensional coordinates of gamma ray photons as it interacts with the face of the camera [Keshtgar 99, Knoll 89]. The photon is emitted from the patient and goes through led collimator, which is used to filter unwanted emissions. The collimator can be pinhole or hexagonal shape, and have a higher sensitivity or resolution or be multi-purpose. Once the photon has passed through the collimator it is absorbed by the scintillation crystal. The crystal is usually NaI(Tl) for many reasons such as cost, scatter properties, and longevity. The energy absorbed in the crystal is redistributed as light emissions, proportional to the energy, that is detected by the PSPMT. The PSPMT will generate an output pulse proportionate to the light that is interpreted by the computer system resulting in an X and Y position. That position is digitized and stored by the computer. The conventional gamma camera typically has a FOV ranging from 300mm in diameter for a single head camera to 400mm x 500mm for the contemporary rectangular head cameras. The

conventional gamma camera is only used for the preoperative images. Once the patient is in surgery the surgeon uses a gamma probe to assist further with localization.

4.3 Counting Probes

The use of a gamma probe in the operating room is similar to a Geiger-Mueller counter in that it functions only as a counter of radiation induced events [Krag 93]. The gamma probe is a non-imaging gamma detector usually containing a single detector. It has a crystal which can be NaI(Tl), CdTe, CsI(Tl), or CdZnTe is attached to a photomultiplier tube. The crystal ranges in size from 5 to 20mm in diameter [Dusi 01]. Although the most commonly used radioisotope for SLN localization is Tc-99, the system for a gamma probe is designed for an energy window that is capable of handling most commonly used radionuclides for intraoperative surgery (Table 4.1.). There are certain characteristics that are important to a gamma probe that is used intraoperatively for surgery [Tiourina 98];

1. Sensitivity
2. Resolution
3. Ergonomics

An intraoperative gamma probe should have a high signal to noise ratio. The ability of the probe to be able to detect nodes that may not have as much activity or that are behind fatty tissue is very important. The gamma probe should have adequate shielding to prevent background radiation and scatter from other tissue, organs and the injection site to interfere with localization. The minimum shielding for gamma probe used intraoperatively should be 3mm of tungsten or lead inside the probe itself this is to offer a factor of 1000 shielding against Tc-99 []. Side shielding is important to reduce the noise entering the side walls of the probe; this is important if the hot sentinel node is in the

proximity of the injection site. The software for the gamma probe should have the option of setting a window around the photopeak to help discriminate against scattered photons. The ergonomic details of the probe are important to the surgeon who has to use the probe. Weight, sound and display all affect the surgeons decision when choosing a gamma probe to use. Some surgeons rely solely on the sound when searching for the nodes and some surgeons rely on the sound and count display. The probe must also be easy to use in a sterile field.

Table 4.1 Radionuclides commonly used for intraoperative surgery

Radionuclide	Energy (kev) of primary emission
Tc-99	140
I-123	159
In-111	171 and 245
Co-57	122
F-18	511

4.4 Intraoperative Gamma Cameras

The small field-of-view (FOV) hand-held gamma camera is a more recent technology. The hand-held gamma camera is used to assist the surgeon to localize the sentinel nodes during surgery; it is used in conjunction with the surgical gamma probes and not meant to replace the probes. There are currently nine companies with small gamma cameras. Most of the cameras have a FOV that range from 2 cm x 2 cm to 5 cm x 5 cm or 10 cm x 10cm to 20 cm x 20 cm [Aarsvold 05]. Although the larger size cameras are still considered hand-held devices they are heavier, weighing no less then a kilogram; which makes them more difficult to maneuver during surgery. The technology is the same as the conventional gamma camera. It consists of camera face, scintillation crystal, collimators,

PSPMTs and a computer system. The scinitlation crystal varies depending on the designer; CsI(Na), NaI(Tl), CdZnTe, or CZT. With several groups working on the development of small gamma cameras, some camera designs are based on a single PMT and some are based on multiple PMTs [McElroy 00]. The size of the camera allows the user to place the camera face in closer proximity of the body then the larger conventional gamma camera. In breast cancer cases this is important because the camera can be placed directly against the breast at different angles, depending on the camera design [McElroy 00]. Just as with the surgical gamma probe: sensitivity, spatial resolution and ergonomics are key characteristics to focus on when developing a system. Ergonomics is just as important as sensitivity and resolution. The surgeon must be able to handle a camera easily within the limitations of a sterile field. The main goal for the hand-held camera differs depending on the developer. Some developers want to design the camera to replace preoperative imaging others have a goal to develop a way to more quickly intraoperatively identify nodes that are difficult to find using only a gamma probe [Aarsvold 05]

CHAPTER 5: METHODS AND MATERIALS

5.1 Investigation Overview

In this and the next two chapters, we present descriptions, results, and discussions of the clinical investigation conducted in this research. Presentation of the material focuses on two studies. One involves melanoma patients; the other involves breast cancer patients. In this chapter, we present the methods and materials used in the two studies. Both studies were conducted only after all necessary approvals were obtained from the appropriate entities (institutional review boards, research and development committees, and radiation safety committees) at the VAMC—Atlanta, Emory University, and GA Tech.

The general purpose of our clinical investigation was initial assessment of intraoperative imaging with a relatively small FOV gamma camera—in the context of SLN procedures. Over three years, 44 patients with melanoma or breast cancer with no clinical evidence of disease spread and scheduled for surgeries that included SLN procedures were consented and enrolled in our studies. All study subjects received all standard management and in addition

The methods used for the SLN localization in our investigation are part of the standard protocol for surgeons at Emory University Hospital. The added procedure to the protocol was the use of a relatively small FOV gamma camera by the surgeon and scientific staff. Data from nineteen melanoma subjects and twenty-two breast cancer subjects were acquired for the characterization of a relatively small FOV gamma camera for the intraoperative use in SLN localization. The procedure for the patients included injections

of a radioisotope tracer, preoperative imaging with a conventional gamma camera, intraoperative injection of blue dye, intraoperative gamma counting, intraoperative imaging, resection of SLNs, a complete pathology report and follow up care.

5.1.1 Description of Melanoma Study

Nineteen subjects were enrolled in this study. The Emory protocol for melanoma surgeries with SLN procedures was followed, however, intraoperative imaging using a relatively small FOV gamma camera was added to the protocol. The Emory melanoma SLN protocol includes injection of Tc-99m sulfur colloid, preoperative gamma imaging and gamma counting, intraoperative gamma counting, injection and visualization of blue dye, resection of tissue and pathological examination of excised tissues. The addition of the intraoperative imaging did not alter significantly any aspects of the standard SLN procedure.

5.1.2 Description of Breast Cancer Study

The methods in study 2 included more details than in study 1. In addition to the two main tasks, the first task was divided into a more defined study where the subjects were divided into two branches. The first six subjects were preliminary cases that allowed the surgeon to get acclimated to the camera; the methods were similar to that of the melanoma cases. The procedure was different for the remaining sixteen subjects. They were split into two branches: the first branch was the probe/dye (PD) branch and the second was the camera/probe/dye (CPD) branch, the cases were randomly assigned to either branch. The two branches were compared to see what the differences were, if any, by adding the intraoperative gamma camera to the surgeries. In all cases, the surgeon was

blinded to preoperative images until the protocol was complete, unless she stated otherwise.

5.2 Methods and Materials Common to Our Studies

5.2.1 GammaCAM/OR

The relatively small FOV (5in x 5in) (12.5cm x 12.5cm) gamma camera, a GammaCAM/OR (Gamma Medica Inc., Northridge, CA), used in this study was developed as a dedicated scintillation camera for breast and lymph node imaging [McElroy 00]. The camera was designed in response to the large bulky size of conventional gamma cameras and the limited spatial resolution [McElroy 00]. The GammaCAM/OR consists of the camera head mounted on a Leica surgical microscope arm with counter balance ability, mounted on a stand that contains the CPU, keyboard and monitor, Figure 5.1. The camera was used with a low-energy, high-resolution (LEHR) collimator (135 cpm/μCi). The camera head with out the collimator weighs fourteen pounds; with the collimator the weight is approximately twenty-two pounds. The camera consist of a 56 x 56 array of 2mm x 2mm NaI(Tl) crystals and a 5 x array of 1in x 1in PSPMTs. During surgery the camera head and the surgical arm had to be covered with a surgical sheath to be used in the sterile field.

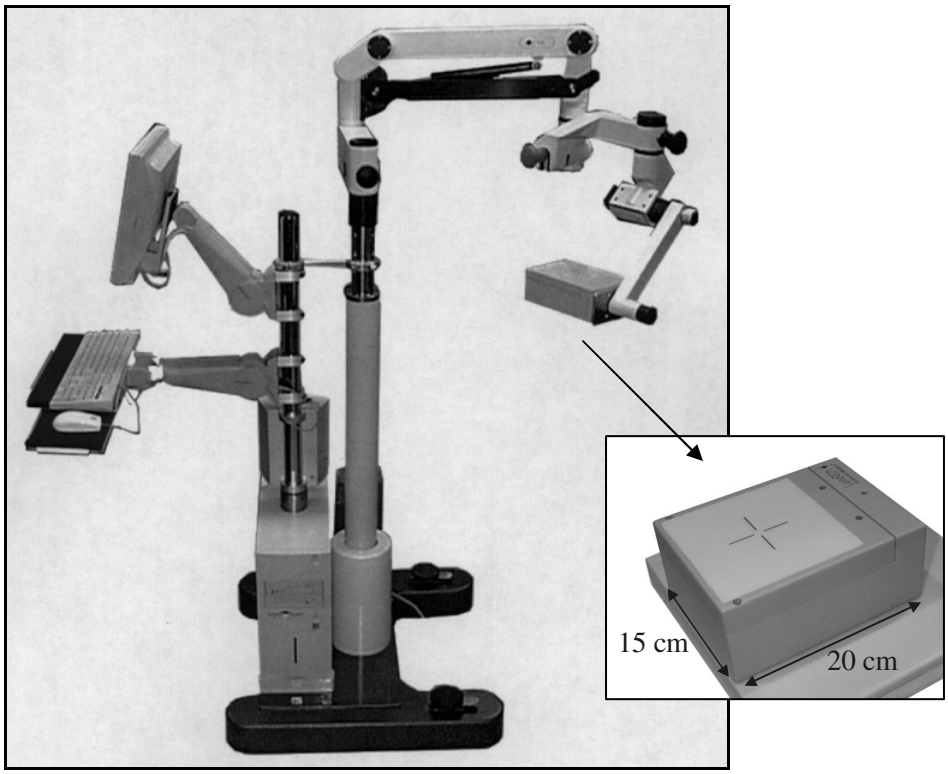


Figure 4.1. Gamma Medica Gamma CAM/OR system. The camera face is connected to a microscope arm which is connected to a stand. The camera has a 56 x 56 array of 2mm NaI(Tl) crystals and a 5 x 5 array of 1"x1" PSPMTs, which results in a 5"x 5" field of view.

5.2.2 Camera Calibration

On the day of each surgery the quality control (QC) checks were completed on the small FOV gamma camera, as with any piece of nuclear medicine equipment. A full calibration was done as needed, which was determined by doing routine QC check. A dose, 400μCi - 650μCi, Tc99m was used to make a flood source; the dose was added to a plexiglass flood tank designed to fit on the face of the gamma camera. The isotope was obtained from the nuclear medicine department of the location of the camera, Emory University Hospital or VAMC-Atlanta nuclear medicine department. A syringe was used to deposit the radioisotope and water into the flood tank; the flood tank was then placed on the

camera face. The QC was performed, if the results were acceptable, a standard deviation of 4.5% or less, the QC was not repeated, if the results were unacceptable then the QC was repeated or the system was calibrated. The camera was ready for surgery once the QC check was satisfactory

5.2.3 Pathology

All excised tissue was collected and carefully labeled. The specimens were sectioned by serial 5-μm sectioning, and were examined histopathologically with routine hematoxylin and eosin (H&E staining) and immunochemical staining (IHS) for S-100 protein and melanoma associated antigen HMB-45 [Carlson 03, Carlson 02]. Some tissue was removed as a single specimen but pathology found the single specimen contained multiple sentinel nodes, and some specimens were not recognized as sentinel nodes. Results of this procedure are sent immediately to the operating room as they can sometimes affect the surgical procedure. The lymph nodes were examined within thirty minutes of resection. If the frozen section H&E staining was positive, the patient was labeled positive for metastasis. If the frozen section was negative, further testing was done. The additional testing was IHC staining. The IHC analysis uses a pan-cytokeratin antibody to detect micrometastases. The slides were reviewed, and the size of each metastatic deposit, if any, in a SLN was measured with an ocular micrometer.

5.3 Melanoma Study Methods and Materials

5.3.1 Subjects (melanoma)

The subjects for the study were nineteen patients (9 male, 10 female) from a time period of three years, all scheduled for SLN resection surgery. A summary of characteristics of the subjects is located in table 5.1. The sites of the primary tumors were located: 7 trunk, 2 head and neck and 10 extremities (5 upper, 5 lower). The mean age was 51.6 years.

Table 5.1 Melanom Subject Characterization

Subject	Sex	Age	Location
Me01	M	72	rt posterior/trunk
Me02	F	42	abdomen/trunk
Me03	F	55	rt upper arm/ extremities
Me04	F	56	rt forearm/ extremities
Me05	M	51	posterior neck/ head & neck
Me06	M	71	rt forearm/ extremities
Me07	F	39	lower back/ trunk
Me08	F	31	lt leg/ extremities
Me09	F	39	rt leg/ extremities
Me10	F	41	lt thigh/ extremities
Me11	M	46	lt arm/ extremities
Me12	M	56	rt forearm/ extremities
Me13	F	33	rt buttuck/ trunk
Me14	M	72	rt leg/ extremities
Me15	F	53	back shoulder/ trunk
Me16	M	69	anterior neck/ head & neck
Me17	M	50	lt foot/ extremeties
Me18	M	44	lf shoulder/ trunk
Me19	F	61	back/ trunk

5.3.2 Radiopharmaceutical injection (melanoma)

On the day of surgery each subject was prepared for the preoperative imaging. The subjects lay down on the imaging table and were positioned by a nuclear medicine technologist. Each subject received 4 injections of 0.22-µm filtered ^{99m}Tc sulfur colloid. The subjects received a total of 125µC to 240µC of injected dose. The intradermal injections were administered around the primary tumor site. Prior to the injections, all syringes were shaken to ensure the colloid was suspended in solution and well mixed. The area around the injection was massaged for one to five minutes after the final injection, to facilitate the flow of the radiopharmaceutical away from the injection site and into the lymphatic system.

5.3.3 Preoperative imaging (melanoma)

A GE 400 (GE Healthcare, Waukesha, WI) single-head gamma camera system with a low-energy all-purpose (LEAP) collimator (300 cpm/mCi) was used to do preoperative imaging of the subjects. Immediately following the massaging of the injection site, the image acquisition was started. The first set of images acquired recorded the dynamic flow of the radiotracer through the lymphatic channels and nodes. The dynamic images were taken in ten second frames for ten minutes. Multiple five minute static images up to an hour were acquired; in some patients a two hour injection delay image was acquired. The images acquired included anterior, lateral, and oblique views. Viewing of all three projections, results in a greater understanding of the positions of the nodes; it provides a three dimensional understanding of the location. A cobalt-57 flood source was placed on the opposite side of the subject from the camera, placing the subject between the camera and the source, to obtain a contour for an anatomical reference of the subject. After the

nodes were localized marks were placed anteriorly on the subject using a surgical marker. The marks provided the surgeon with an idea of the location to make the incision.

5.3.4 Blue-dye injection (melanoma)

Subjects were scheduled for surgery from two to eighteen hours after completion of the preoperative imaging. In the surgical suite after the subjects received anesthesia, they were given injections of isosulfan blue dye. This dye migrates into the lymphatic system and provides a possible means of visually identifying SLNs. Three to five injections with a total volume of 5 cc were given. After the dye was administered, the surgeon massaged the injected site for five minutes.

5.3.5 Intraoperative gamma imaging/counting (melanoma)

After the blue dye was administered, the scientist or the surgeon used the small FOV gamma camera to attempt to image the sentinel nodes. In the operating room the surgeon knew were the sentinel nodes were located because of the preoperative images and the mark on the subjects skin. In some surgeries the preincision image was taken before the sterile field was created. Once the area for surgery was prepared the camera head and arm had to be covered by a sterile sheath. In the latter surgeries a radioactive sterile marker was used to assist in positioning the camera head for the image acquisitions. The sterile marker was prepared prior to entering the surgical suite. A medical cotton swab was injected with a few microcuries of Tc-99m, the tip was then covered with medical tape to prevent contamination. Once the camera head was in place to acquire an image the radioactive marker would be placed in the field of view for a ten second acquisition. Using a sterile marker, the edges of the camera would be marked either on the patient

skin or on the sterile drapes. The pre-incision images were typically 3-minutes. After the images were taken the surgeon used the counting probe , Neoprobe 1000/1500 (Neoprobe, Dublin, OH), which was also was covered with a sterile sheath, to confirm the location to make the incision(figure). The surgeon also used the preoperative images and the marks on the subject's skin for reference.

Once the surgeon was confident he had located the area of interest, he made an incision. The counting probe was inserted into the incision and used to locate the node. After localizing the node, the surgeon removed the node and counted the excised tissue ex-vivo. The ex-vivo count of the removed nodes was a ten second count done with the probe directed at the specimen such that the count rate was maximized. The probe was also placed in the excision bed to check for remaining activity. A post-excision image was acquired using the GammaCAM for duration no longer than three minutes. In the cases were the radioactive marker was used, it was placed on the mark made and using the marks for the camera edge the camera was put in place and the post excision image was taken. Excised tissue judged by the surgeon to contain SLNs was imaged for up to 5 minutes to accurately quantify colloid uptake. Some specimens were sent to pathology for frozen-section analysis. The surgeon then completed the surgery with the stitching the excision.

5.4 Breast Cancer Study Methods and Materials

5.5.1 Subjects (breast cancer)

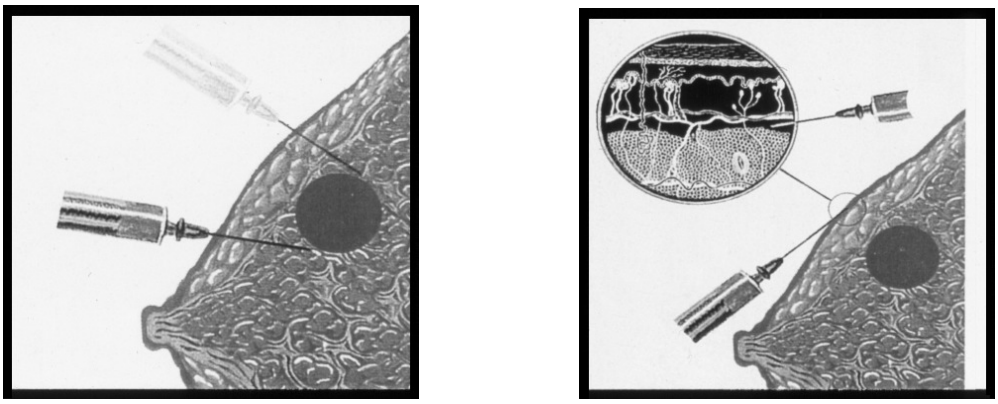
Twenty-two breast cancer patients were enrolled in this study. Six were enrolled in a short pre-study that provided us experience with the small FOV camera and an opportunity to identify and implement final refinements to the study protocol. Sixteen patients were enrolled in the primary study; the patients were randomly assigned to one of two branches. Eight patients were assigned to a branch that involved use of intraoperative gamma counting, gamma imaging, and blue-dye visualization—the probe/camera/dye (PCD) branch. Eight others were assigned to a branch that involved use of intraoperative gamma counting and blue-dye visualization only—the probe/dye (PD) branch. All subjects received preoperative imaging. Some of the subject characteristics are listed in Table 5.2.

5.4.2 Radiopharmaceutical Injection (breast cancer)

On the day of surgery each subject was prepared for the preoperative imaging. The subjects lay down on the imaging table and were positioned by a nuclear medicine technologist. Each subject received three injections, totaling 350 μCi of 0.22-μm filtered 99mTc sulfur colloid. Two of the injections were peritumoral (Fig5.2.) and consisted of approximately 125 μCi in 1 ml. The third injection was subdermal (Fig5.2.) and consisted of approximately 250 μCi in 0.3 ml. Prior to the injections, all three syringes were shaken to ensure the colloid was suspended in solution and well mixed. The breast was massaged for one to five minutes after the third injection, to facilitate the flow of the radiopharmaceutical away from the injection site and into the lymphatic system. approximately 125 μCi in 1 ml.

Table 5.2 Breasty Cancer Subject Characterization

Subject	Sex	Age	Location	Position
Br01	F	78	lt	3:00
Br02	F		rt	3:00
Br03	F	54	lt	2:00
Br04	F	40	rt	9:00
Br05	F	64	lt	2:00
Br06	F	58	rt	2:00
Br07	F	47	lt	2:00
Br08	F	52	rt	3:00
Br09	F	58	lt	2:00
Br10	F	80	rt	8:30
Br11	F	77	rt	11:00
Br12	F	66	rt	9:00
Br13	F	65	lt	1:00
Br14	F	69	lt	6:00
Br15	F	53	rt	0:00
Br16	F	46	rt	10:00
Br17	F	41	rt	12:30
Br18	F	43	rt	6:00
Br19	F	42	rt	11:00
Br20	F	67	lt	3:00
Br21	F	81	rt	12:00
Br22	*	*	*	*



Peritumoral **Subdermal**

Figure. 5.2. Schematic of peritumoral injections. (R) Schematic of subdermal injection. Schematics were adapted from Keshtgar MRS, Waddington WA, Lakhani SR and Ell PJ. *The Sentinel Node in Surgical Oncology*, Berlin: Springer-Verlag, 1999, pp 51, 54.

5.4.3 Preoperative imaging (breast cancer)

A conventional single-head gamma camera, a GE 500 (GE Healthcare, Waukesha, WI), with a low-energy all-purpose (LEAP) collimator (300 cpm/mCi) was used to do preoperative imaging of the subjects (Figure 5.3). Immediately following the breast massage the image acquisition was started. Anterior, lateral and oblique views of 2 to 5 minute duration were taken until radiotracer foci representing possible SLN were adequately visualized. The initial images acquired often helped reveal the dynamic flow of the radiotracer through the lymphatic channels and nodes. The images helped identify the order in which the nodes were visualized, which helps identity sentinel nodes from secondary nodes. A Co-57 source was placed on the opposite side of the subject from the camera to obtain a contour of the subjects body in the image. A single technologist, very experienced in SLN localization procedures, performed all preoperative imaging. Locations on the patients' skin representing the anterior and lateral projections of each preoperatively detected focus were marked with UV fluorescent ink (A-800 blue

chlorine-resistant invisible readmission ink, UV Products, Upland CA). This allowed preoperative markings to be invisible during the procedures required for this blinded study, and yet to be available if required for patient care.

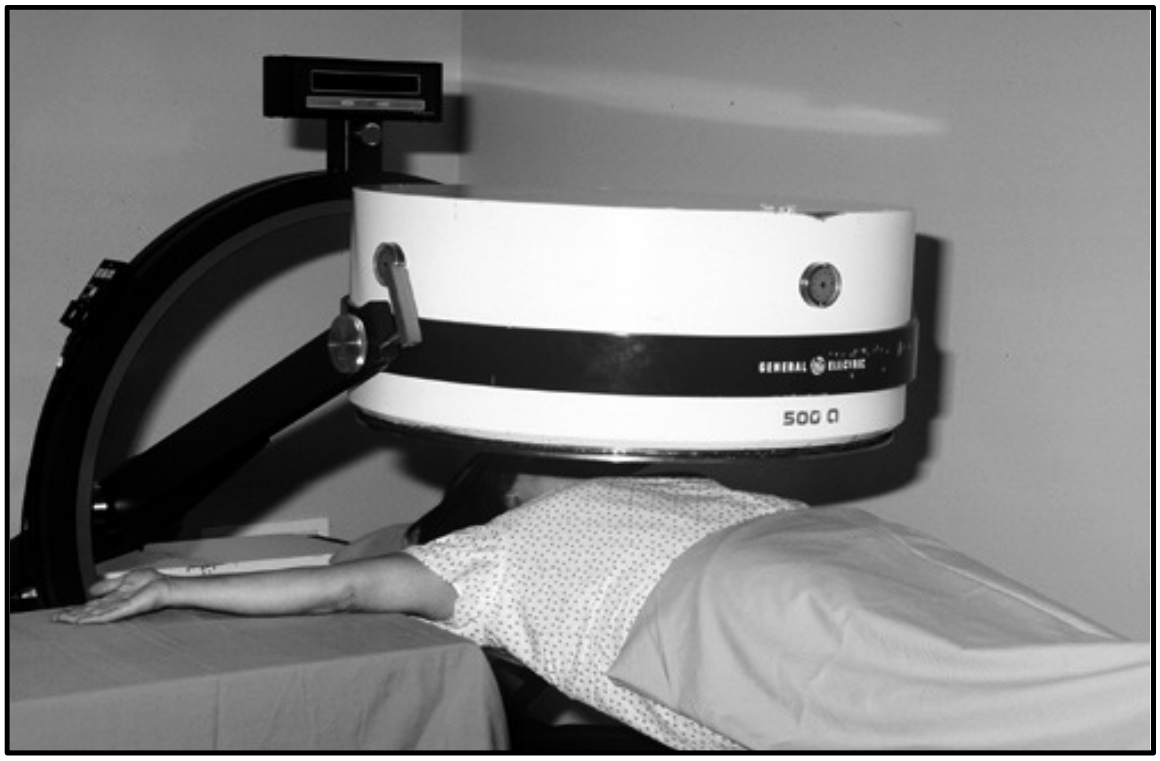


Figure 5.3. Pre-operative imaging using a conventional single-head gamma camera (GE 500 w/ LEAP collimator). The camera is positioned for acquisition of an anterior image. A Co-57 sheet source, used as a transmission source to obtain body contours, is positioned under the imaging table. The patient arm on the side of the involved breast is positioned as it will be during surgery.

5.4.4 Blue-dye injection (breast cancer)

Subjects were scheduled for surgery from two to eighteen hours after completion of the preoperative imaging. In the surgical suite after the subjects received anesthesia, they were given injections of isosulfan blue dye. This dye migrates into the lymphatic system and provides a possible means of visually identifying SLNs. Three to five injections with a total volume of 5 cc were given. After the dye was administered, the surgeon massaged the injected site for five minutes.

5.4.5 Intraoperative gamma imaging/counting (breast cancer)

After the blue dye was administered the surgeon then used the gamma probe to search the axillary and internal mammary regions of the subject. For the PD branch of the study, after the surgeon was confident she had completed the search for the sentinel nodes with the probe she was ready to make her incision. For the CPD branch of the study the surgeon used the small FOV gamma camera to image the sentinel nodes. Once the image acquisition was complete the surgeon was ready to make the incision. The UV light was used to see the marks made by the nuclear medicine technologist as a check for the surgeon. As part of the CPD branch the surgeon used the small FOV gamma camera and attempted to acquire images of the sentinel nodes. Each image acquisition was approximately two to three minutes long. The surgeon made the incision after the probe search or image acquisition. After making the incision the probe was used inside the excisional bed to locate the radioactive tissues. The surgeon then removed the radioactive tissue. The probe was used one last time inside the excisional bed to check for more radioactive tissue or lack of radioactivity and ex-vivo count of the tissue was also taken. If the subject was part o the CPD branch an image of the excisional bed was acquired

after the removal of radioactive nodes and a final image was acquired of the tissue that was deemed by the surgeon to be sentinel nodes. The duration of the excisional bed image was three minutes and the excised tissue was imaged for five minutes.

CHAPTER 6: RESULTS

6.1 Melanoma Study Results

The outcomes of this experiment are mostly qualitative not quantitative. Radioactive foci were visualized in 19/19 cases during preoperative imaging. The intraoperative imaging performed with the hand held gamma camera yielded visualization in 18/19 cases. In the first two melanoma surgeries tissue imaging was not performed therefore analysis on nodal uptake was performed on the latter 17 subjects, 103 exicised samples. Each data acquisition during surgery required at least two persons and added no more than thirty minutes to surgery. A maximum of six lymph nodes were removed from one patient and a minimum of one node was removed. The maximum uptake in an excised tissue was 5386.85 nCi, 4.3% of the total injected activity; the minimum uptake in an excised tissue was 813 nCi, .08% of the total injected activity. The activity of radioisotope in each node removed is located in Table 6.1. A summary of each case is located in Appendix A. Three cases were found to have metastesis in the lymph nodes and were followed with regional lymphectomy. The following are the results of two cases demonstrating findings of the camera.

Table 6.1 Melanoma node activity comparison

Focus	post-ex cts probe	post-ex cts camera	activity	focus / injected
Me03-1	0	49	73	0.000
Me03-2	5921	100	1134	0.522
Me03-3	548	49	45	1.209
Me03-4	423	72	40	1.059
Me04-1	899	63	107	0.840
Me04-2	2831	169	882	0.321
Me04-3	1754	64	180	0.972
Me05-1	939	144	363	0.259
Me05-2	3662	121	434	0.844
Me05-3	1397	81	200	0.698
Me05-4	642	90	190	0.337
Me05-5	1057	121	139	0.762
Me05-6	879	156	195	0.451
Me06-1	644	132	247	0.261
Me07-1	5187	156	1269	0.409
Me07-2	1978	132	339	0.583
Me07-3	1879	168	1740	0.108
Me08-1	24794	420	5387	0.460
Me09-1	6711	196	1607	0.418
Me09-2	13917	195	1706	0.816
Me09-3	5940	208	858	0.693
Me09-4	938	154	255	0.368
Me09-5	694	144	81	0.852
Me10-1	1132	272	466	0.243
Me10-2	452	154	1139	0.040
Me11-1	1143	208	180	0.634
Me11-2	462	168	48	0.953
Me12-1	4630	360	2180	0.212
Me12-2	482	208	133	0.363
Me13-1	3104	272	433	0.718
Me14-1	1773	256	337	0.526
Me15-1	1368	342	504	0.271
Me15-2	1615	238	375	0.431
Me15-3	7125	441	1019	0.699
Me16-1	2118	342	223	0.951
Me17-1	10817	621	3481	0.311
Me18-1	16376	225	3191	0.513
Me18-2	4234	195	1326	0.319
Me18-3	1194	288	186	0.641
Me18-4	3386	324	544	0.623
Me19-1	844	240	110	0.766

6.1.1 Melanoma Example Case 1

The first example is a fifty-six year old male with the primary lesion located on the right forearm. The images below (figure 6.1b-c) are intraoperative images taken with the small field-of-view gamma camera. The camera was successfully repositioned after the excision of the sentinel lymph nodes from the axilla using a radioactive marker. The successful repositioning of the camera after removing the lymph nodes allowed the surgeon to get an image of the axillary region in the same location as the pre-excision image.

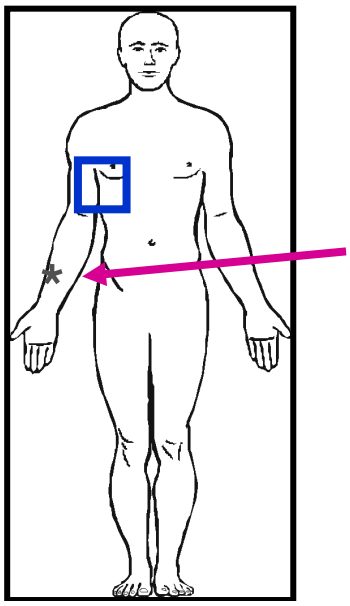


Figure 6.1a . Primary lesion is located on the right forarem. The camera was placed in the right axilla for imaging.

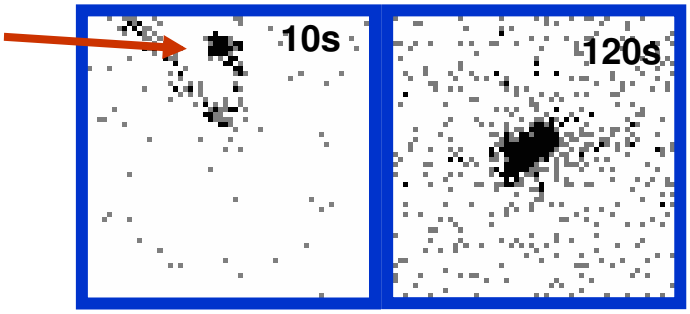


Figure 6.1b. A 10 second image with a radioactive marker placed in the imaging field acquired using the small FOV camera. A preincision image with the camera in the same location.

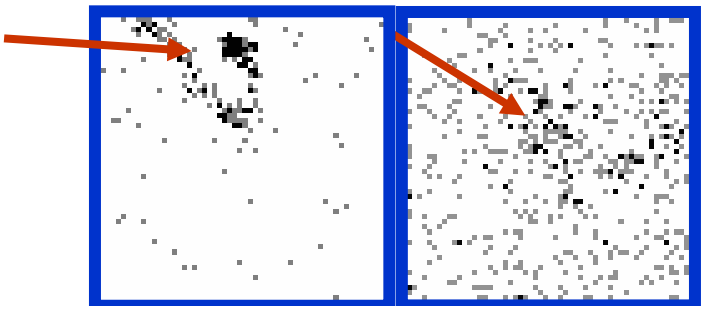


Figure 6.1c. A 10 second image with a radioactive marker is taken post excision in order to reposition camera. A post-excision image taken shows activity was removed

6.1.2 Melanoma Example Case 2

This case is a 51 year-old male with the primary lesion that was located on the distal dorsum of the left foot. The preoperative images are shown in figure 6.2b, with the two views lateral and anterior the surgeon can get a sense of depth of the node inside the tissue. The intraoperative images below also show an anterior and a lateral view, figure 6.2c. Using the same radioactive marker technique intraoperatively the camera is positioned and repositioned in the same location for prexcision and postexicsion imaging; showing clearly the node removed postexicision and the residual activity.

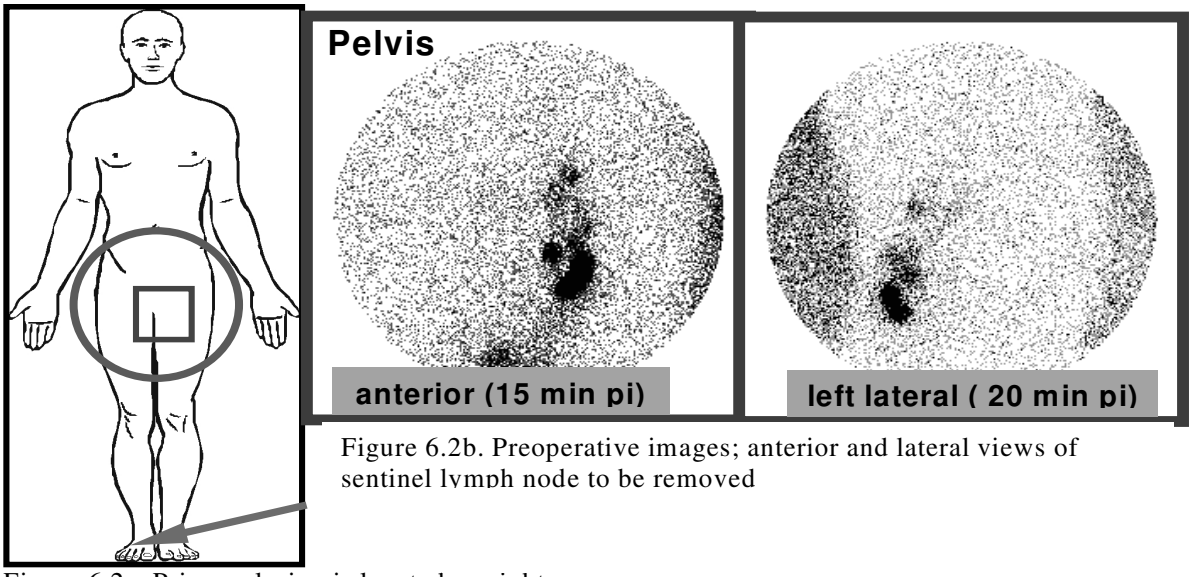


Figure 6.2b. Preoperative images; anterior and lateral views of sentinel lymph node to be removed

Figure 6.2a. Primary lesion is located on right foot. Imaging is done in inguinal axilla.

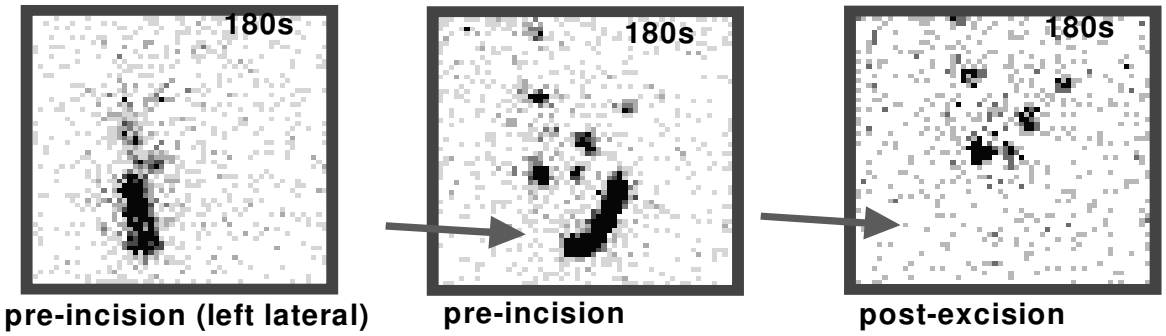


Figure 6.2c. Intraoperative images acquired with small FOV camera: Pre-incision lateral image of sentinel node, Anterior pre-incision image acquired showing multiple nodes located in the same area, Post-excision image taken in the same place shows larger activity was removed.

6.2 Breast Cancer Study Results

The first six subjects were cases that allowed users to get acclimated to the small FOV gamma camera and develop a more defined comparison for the remaining cases, therefore some of the results are based on the later sixteen cases and some are based on the first six. In the first six cases the maximum uptake of activity for a single tissue sample was 12984 nCi, 4.5% percent of the injected activity; the minimum uptake for a single tissue sample was 29 nCi, .09% of the injected activity.

In the latter sixteen cases preoperative imaging resulted in foci visualization in 16/16 patients. Intraoperative external detection of the radioactive nodes using the gamma probe was accomplished in less than 4 minutes with a mean time equal to 1.5 minutes in 15/16 patients; external detection was accomplished using the gamma camera in 6/8 patients. The average time for completion of excision of nodes was 19 minutes for probe/dye and 28 minutes for camera/probe/dye. In one probe/dye case, review of the preoperative images prompted the surgeon to resume axillary dissection and remove one additional SLN. Two cases will be shown as an example.

6.2.1 Breast Cancer Example Case 1

Case 1 is a 49 year-old woman with lobular carcinoma on her right breast. The preoperative images demonstrate several foci of uptake, including foci located in axillary and internal mammary beds. In surgery, five radioactive tissue samples were excised from the axillary region; none were removed from the internal mammary region (Figure 6.3). Intraoperative imaging showed that the foci in the area of interest had been completely removed from the nodal bed. Specimen imaging of the five excised samples (figure 6.4) demonstrated that nodal uptake ranged from 0.1% to 1.5% of the injected

dose (500 μCi). At the time of imaging, several hours post injection, the specimens contained 300 to 3750 nCi of Tc-99m, 0.1 to 1.5% of the decay corrected injected dose, table 6.2.

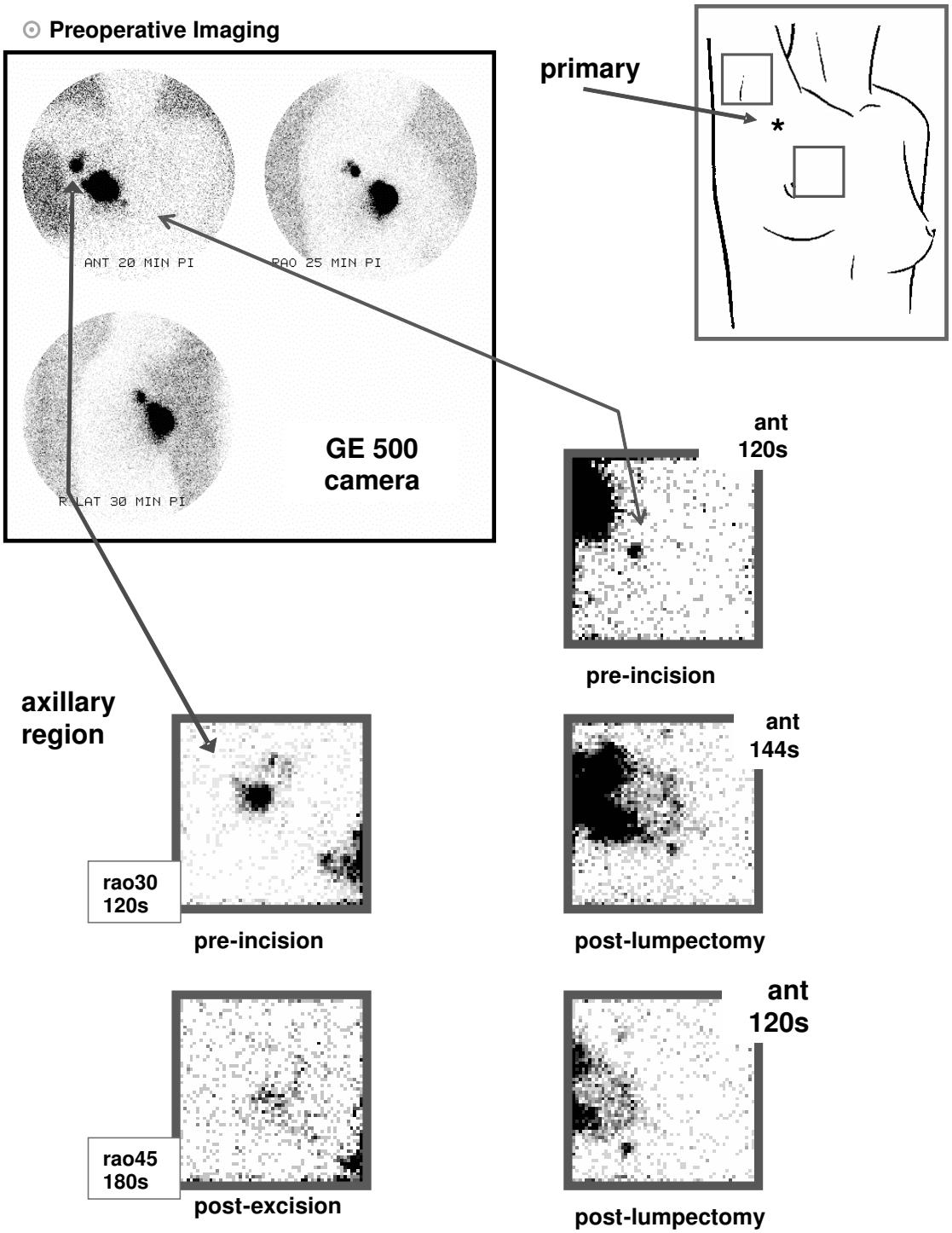


Figure 6.3. Breast case 1. A 49 year old female with lobular carcinoma on her right breast. The preoperative image shows a foci in the axillary and internal mammary region. The small FOV camera was placed in the right axilla and internal mammary areas for the image acquisitions. The intraoperative images show the corresponding foci in the axillary and internal mammary regions. The axillary intraoperative images has pre and post excision images, showing the radioactive node was removed succesfully. The intraoperative post-lumpectomy images show the focus that the surgeon did not remove from the internal mammary region.

Specimen Imaging

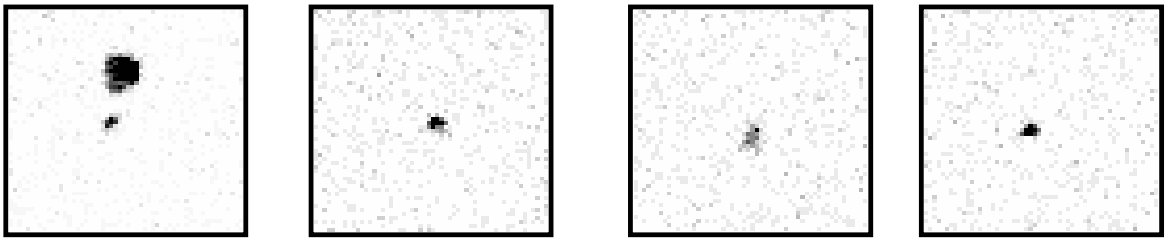


Figure 6.4. Specimen Imaging. Five nodes were removed from the axillary region in case 1. The first three nodes were sentinel nodes, deemed by the surgeon and the last two lymph nodes were secondary axillary nodes. The images were a result of three minute acquisitions using the small FOV gamma camera.

Table 6.2 Specimen intraoperative imaging

Specimen ID	Post-excision counts 10s (probe)	Activity (nCi) camera	specimen/injected activity (%) (camera)
1(SLNax)	**7958**	3740	**1.46**
2(SLNax)	1262	376	0.15
3(secLNax)	3190	459	0.18
4(secLNax)	829	267	0.11
5(secLNax)	**2085**	300	**0.12**

Note that the hand-held probe counts do not accurately reflect the activity in the specimens as determined using the camera images and the camera's sensitivity. The probe count rate is too sensitive to small changes in positioning relative to the sample, as well as to variations in sample activity distribution.

6.2.2 Breast Cancer Example Case 2

Case 2 is a 40 year-old female with an infiltrating ductal carcinoma on her right breast. Preoperative images demonstrate multiple foci of uptake (Figure C). Three channels of uptake are visible. In surgery, only one radioactive tissue sample was excised from the axillary region. Preoperative, intraoperative, and specimen imaging suggested the excised tissue contained more than one node. The specimen had two nodes: one 2 cm in diameter and one 4 cm in diameter. A large fraction, approximately 4.5% of the injected dose, was absorbed and retained by the nodes; at the time of imaging almost four hours post injection the node contained approximately 13,000 nCi of Tc-99m. The remaining node, shown as the post injection secondary lymph node (secLN) in Figure C was deep in the nodal basin.

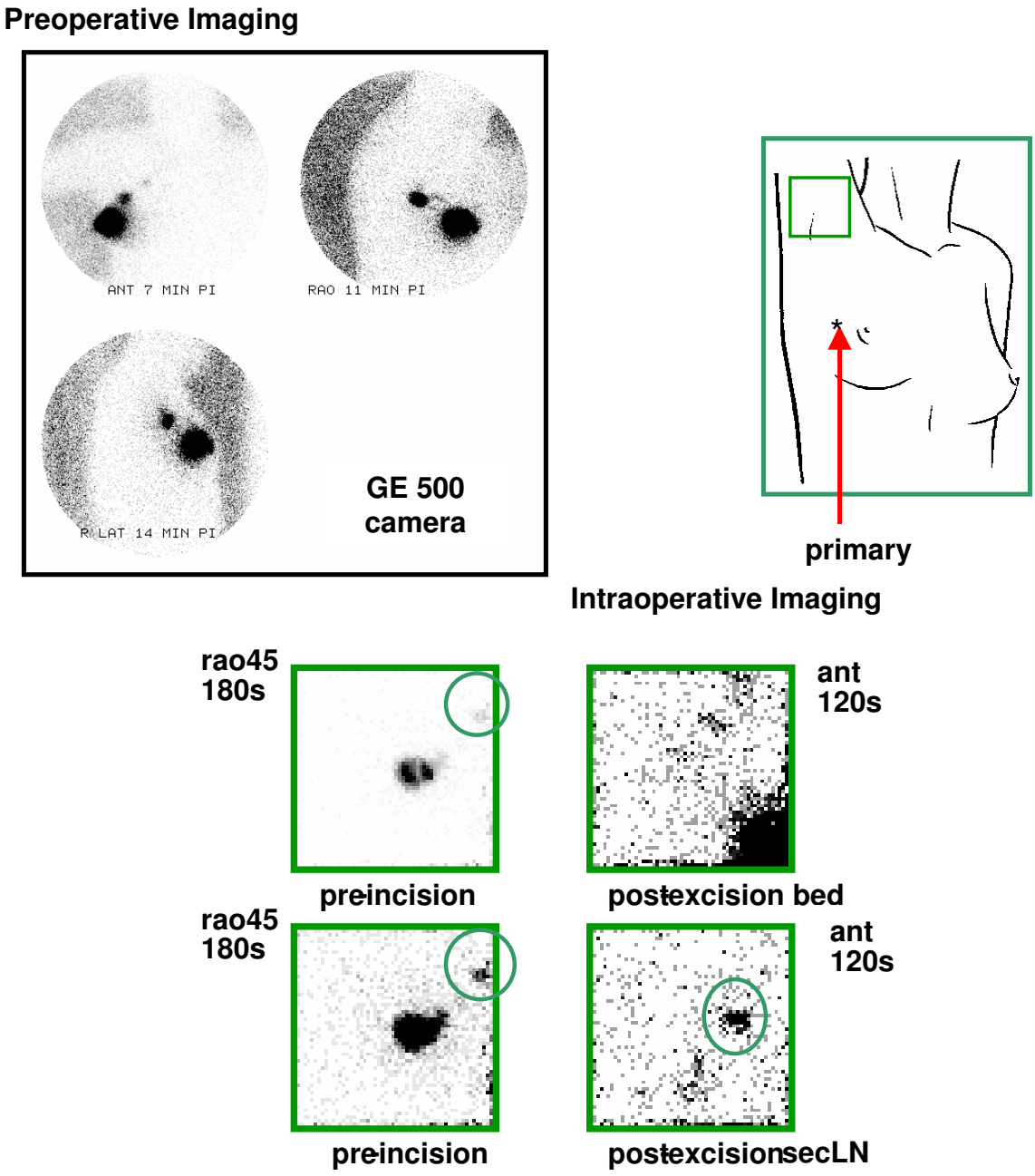


Figure 6.5. Breast case 2 The preoperative image shows a large foci located in the right axilla as well as visable channels from the injection site to the foci. The small FOV camera was placed in the right axilla for image acquisisition. Only one focus was removed and secondary foci are left in place.

CHAPTER 7: DISCUSSION

7.1 General Discussion

In this study the investigation of the use of a small FOV gamma camera, A Gamma Medica GammaCAM/OR, for intraoperative detection and localization of SLNs in melanoma and breast cancer cases. The essential goals in a SLN protocol are detection and localization of all the SLNs. The SLNs have to be detected in order to be resected and biopsied,

7.2 Melanoma Study Discussion

The preoperative imaging resulted in visualization of foci in all 19 cases. An experienced nuclear medicine technologist in the Nuclear Medicine department of Emory University Hospital performed the preoperative imaging. The intraoperative imaging performed using the small FOV gamma camera yielded visualization in all but one of the nineteen cases. The one case that the intraoperative camera did not yield a focus was a more difficult case due to the attenuation from a larger body mass and breast tissue, the activity decay due to a five hour time difference, and the shine through from the injection site. After making the incision the surgeon had to search further and deeper to locate the node for removal. This case demonstrated the limitations of having a smaller FOV camera and working in the operating; the technologist was only able to visualize the node preoperatively after an hour of imaging and six different camera positions. If there was a case that the surgeon had to survey the lymphatic regions in a case without having preoperative imaging, using a camera with a FOV smaller then the one used in this investigation would not be beneficial and would be very time consuming.

The details of a SLN protocol make a significant difference. The important details related to the research performed were: 1. The surgeon is a very skilled and experienced, 2. The nuclear medicine technologist were experienced, 3. There was a good working relationship between the surgeon and nuclear medicine staff, and 4. The surgeon used quality preoperative images. After experiencing the nineteen melanoma cases it was not evident that under the listed circumstances a small FOV gamma camera would add value to such a surgical protocol. However as a result of participating in the nineteen surgeries the protocol for using the intraoperative camera was improved upon. One of the limitations of having a small FOV camera is the lack of anatomical reference. It was evident that camera could be successfully repositioned, after excision and node removal, in order to obtain an accurate assessment of the excisional bed. Accurate repositioning of the camera allowed the surgeon to visualize any residual activity remaining in the excisional bed, assuring the surgeon that the foci had been removed. As shown in melanoma case 2 the radioactive marker was placed in the preexcision image and the postexcision image giving users an image of residual activity. It should be noted because of movement from cutting, cauterizing and stretching the tissue will not be exactly as it was prior to incision.

Imaging the tissue ex vivo gave additional information for research purposes; there was no direct benefit to the subjects or the surgery. The gamma camera gave more information than using the gamma probe ex-vivo. The information obtained about the nodes could be used for future work on intraoperative imaging and radioisotopes in the operating room. The surgeon does not know exactly how many nodes has been resected

until the results from pathology has returned. The surgeon only knows how many tissue samples have been excised only pathology can accurately determine the number of nodes in a tissue sample.

7.3 Breast Cancer Study Discussion

The procedures for the first six breast cancer cases were similar to the melanoma procedures. In the latter sixteen cases the study was more defined and the cases were split into two branches. The preoperative imaging for all the cases was performed by a skilled nuclear medicine technologist in the Nuclear Medicine department of the VAMC-Atlanta. In the preoperative imaging, foci was visualized in all the cases, 6/6 and 16/16. Although the blue dye was used all the radioactive nodes resected were not blue and some blue nodes resected were not “hot”; those nodes that were not “hot” were sent to pathology as secondary nodes. In the latter sixteen cases, the subjects were split into two defined branches; the C/P/D branch and the P/D branch. The important details that were constant in both branches of this study were: 1. A skilled surgeon performed all the surgeries, 2.Quality preoperative imaging was performed by a skilled technologist, and 3. A gamma probe and blue dye were used intraoperatively in all surgeries. As the surgeon was blinded to all preoperative imaging, a mean time of less1.5 minutes was needed to localize the radioactive foci externally using the gamma probe. Intraoperative preincision counting using the gamma probe was successful in 15/16 cases. Intraoperative external detection using the gamma camera was accomplished in 6/8 cases. In one case, which was missed by both the probe and camera it was difficult because the node did not have a substantial uptake; in the preoperative images the focus did not have many counts and there was less activity due to decay during surgery which did not commence until five

hours late; in the other case the injection site was too close to the node. The surgeon was skilled using the gamma probe, however there is always uncertainty of how many nodes there are, having the preoperative images greatly reduces the uncertainty. The intraoperative camera did not add value to the procedure prior to incision and the excision of the foci under the specific circumstances. The surgeon did mention in one case that the camera help confirm that the radioactive nodes had been removed after performing post-excision image. It is possible the small FOV gamma camera could have added value in confirming the removal of radioactivity from the excisional beds. It is also possible that under other circumstances the camera could have added value in other aspects.

CHAPTER 8 : CONCLUSIONS, OBSERVATIONS, FUTURE DIRECTIONS

8.1 Review

Intraoperative imaging in SLN protocols was the primary topic of this investigation. Specifically, we investigated the use of a relatively small FOV (12.5cm x 12.5cm) gamma camera, a Gamma Medica GammaCAM/OR, for intraoperative imaging in melanoma and breast cancer SLN biopsy procedures. The investigation included 41 subjects, 19 melanoma and 22 breast cancer patients. Intraoperative imaging was performed in 33 of the surgical procedures. The reported investigation is the most extensive clinical evaluation of the use of intraoperative imaging with a small or relatively small FOV gamma camera yet performed.

8.2 Conclusions

8.2.1 Melanoma Study Conclusions

In the melanoma study, we investigated the incorporation of intraoperative imaging into a well-established melanoma SLN biopsy procedure. The imaging incorporated was performed using the GammaCAM/OR. Nineteen patients were enrolled in the study. The primary conclusion of the study is intraoperative imaging with a relatively small FOV gamma camera can be incorporated into melanoma SLN procedures. However, the addition of a relatively small camera to a well-established protocol that includes; preoperative nuclear medicine imaging, intraoperative gamma counting, intraoperative blue-dye visualization, and surgical procedures performed by a surgeon with extensive experience in melanoma SLN procedures, is of limited added value as regards the detection and localization of possible SLNs.

In a few cases in this study, the surgeon noted that post-excision intraoperative images of some excisional beds helped him to more rapidly conclude that all radioactive foci that were possible SLNs had been excised. There is the possibility that in these cases there was added value through increased surgeon confidence that the resection procedure was complete and fully successful. Our study was not designed to assess that specific form of possible added value. Additional investigations specifically designed to assess such may be useful. Our experience however, does suggest that preoperative imaging is a critical feature of melanoma SLN procedures and should be a component of all melanoma SLN procedures. We suspect that the addition of intraoperative imaging to a procedure that includes preoperative imaging will almost always have limited added value as regards the localization of possible SLNs.

We note, to be clear, the results of this study are limited to the specific context of our investigation. It is not prudent to extrapolate our results beyond the context of this study. For example, assessment of the value of the addition of intraoperative imaging to a melanoma SLN procedure in which preoperative imaging is not included or in which intraoperative imaging is done with a large FOV camera rather than a relatively small one or in which the surgeon has limited experienced or is even a trainee has not been addressed by this investigation. Intraoperative imaging may have value in one or more of these contexts; our investigation was not designed to address these contexts directly.

8.2.2 Breast Cancer Study Conclusions

Two studies were performed with breast cancer patients as subjects. The first was a small study in which intraoperative imaging with the GammaCAM/OR was simply added to a well-established breast cancer SLN biopsy procedure. Six patients were enrolled in this preliminary study. The results of this first study were used to finalize specifications for our primary breast cancer study and to provide the investigative and surgical teams opportunities to become familiar with the technology and protocols of the investigation.

The primary breast cancer study was a two-branch study in which subjects were randomly assigned to one of the two branches. Sixteen subjects, eight in each branch, were enrolled in this study. In one branch, we used a well-established breast cancer SLN procedure which included intraoperative gamma counting with a gamma counting probe. In the other branch, we used a modified version of the same SLN procedure. The modification to the SLN procedure was the addition of intraoperative imaging with the relatively small FOV gamma camera. One other modification of the well-established procedure was added to both branches of the study. Preoperative images were acquired as part of the established procedure, but the surgeon was blinded to the results of the imaging until all study aspects of the surgical procedure were complete.

The main conclusion of the primary breast cancer study is a surgeon with extensive experience in breast cancer SLN procedures may find limited added value in the addition of intraoperative imaging to a well-established SLN procedure that does not include preoperative imaging. However, a definitive assessment of the nature and amount of added value that can result from the use of intraoperative imaging requires additional

investigation. Our experience suggests factors that should be well defined in such investigations include: detailed specification of the other detection/localization techniques included in a procedure, skills/experience of the participating surgeons, the size of the FOV and the sensitivity of the camera to be used, and the ease of use of the imaging system, particularly the ease of positioning of the camera.

Many surgeons use preoperative imaging, but many do not. Our results suggest that including intraoperative imaging in procedures that do not include preoperative imaging will prove useful in some cases, but likely only in a few cases if the procedures are performed by a very experienced surgeon. It is expected that there would be minimal added value from adding intraoperative imaging to a procedure that includes high-quality preoperative imaging and an experienced surgeon would be minimal.

Similarly with the results of the melanoma study, the results of this study should not be extrapolated beyond the context of this investigation. Parameters that appear critical to the results of this study include: a very experienced surgeon; blinding the surgeon to the results of preoperative imaging—thus, the absence of preoperative images; intraoperative imaging with a relatively small FOV gamma camera as opposed to a camera with a small or large FOV; and technical aspects of the imaging system, e.g., camera sensitivity and ease/non-ease of camera positioning.

An overall conclusion from our studies is SLN procedures which include preoperative imaging that are modified to include intraoperative imaging using a relatively small FOV

gamma camera; is unlikely to produce a measurable improvement on SLN detection rates; however, SLN procedures performed using protocols that do not include preoperative imaging may be enhanced if a surgeon has access to the visual information that intraoperative imaging can provide.

8.3 Observations

Most research suggests that melanoma and breast cancer SLN protocols that include preoperative nuclear medicine imaging will result in higher SLN localization rates than those that do not. However, for various reasons, it is not always possible to obtain high quality preoperative images, and. thus, not all such SLN protocols include preoperative nuclear medicine imaging. Investigation of the use of intraoperative imaging in protocols that do not include preoperative imaging should continue as intraoperative imaging in some form may yet prove significant in some contexts.

The patient studies reported above were not designed to investigate specifics about technology requirements. However, experience gained in the investigation leads us to the following observations. Camera sensitivity is much more important than camera resolution for the task of intraoperative localization of SLNs in a melanoma or breast cancer patient. Accurate camera positioning and repositioning together with ease of positioning and repositioning are important if intraoperative imaging is to be performed and surgical resources are to be used efficiently and effectively. A camera's FOV should quite likely be larger than that which we used as the nominal areas that need to be searched for possible SLNs are larger than the FOV of the camera we used.

Camera sensitivity is important because the simple task of imaging a focus representing significant radioactive uptake is straightforward. What is not straightforward is the imaging of a focus of small uptake (uptake of only 100s or even 10s of nanocuries). Some SLNs have very little uptake, yet intraoperative imaging protocols must be such that low uptake nodes are routinely detected and localized. Ease of camera motion is also important. An intraoperative camera system should be such that its camera can be moved effortlessly and simultaneously positioned accurately at any location within the entire sterile field. If this is not the case, surgical effort and surgical time are increased, often significantly. SLNs are found in many locations relative to a tumor, particularly in melanoma patients, but also in breast cancer patients. The size of a camera's FOV remains an issue. For SLN procedures for melanoma and breast cancer and for many other cancers, our experience suggests that intraoperative imaging might be more effective if cameras with moderately large or large FOVs were used. Such cameras would in one image acquire the information a relatively small FOV system only acquires with two, three, or even four images.

8.4 Future Directions

Our investigation focused on the use of a relatively small FOV gamma camera for intraoperative localization of SLNs in patients with melanoma or breast cancer and used procedure parameters of specific well-established SLN biopsy procedures. As indicated above, there are many variants of our investigation that might be pursued. A possible direction of future investigation would be one in which studies similar to those we have performed would be conducted. The studies would enroll melanoma and breast cancer patients as we did, but the investigations would differ from ours in that they would

involve different gamma camera technologies and/or they would use surgeons with different levels of experience than those in our investigation.

An interesting direction of research would be one designed to develop SLN protocols for cancers for which preoperative nuclear medicine imaging is difficult at best—difficult because appropriate preoperative injection of a radiopharmaceutical is difficult. Consider lung and colorectal cancers, for example. A few SLN procedures have been conducted on such patients, but no SLN procedure for routine use for patients with such cancers exists. Radiotracer injections around lung and colorectal cancers, if attempted preoperatively, would likely need to be performed under CT guidance—an exercise that would be quite difficult in many cases. A possible alternative to preoperative injection and imaging, if intraoperative imaging is a viable option, is intraoperative injection of a radiopharmaceutical after surgical opening followed by intraoperative imaging. Our efforts have demonstrated intraoperative imaging for SLN localization is feasible if radiotracer injections are administered preoperatively. Development of intraoperative SLN procedures for cancers such as lung and colorectal require development of practical (time limited) intraoperative procedures for SLN localization. The work we have reported provides a solid foundation for expectation that successful SLN protocols can be developed for cancers such as lung and colorectal even if such protocols require intraoperative injection and imaging of radiopharmaceuticals. However, our investigation also makes it clear that developing and refining such protocols will not be an easy task.

APPENDIX A

ME01

5x5 Patient: ME01

Date of Study: 12/20/01

Patient Initials: AB

Patient History:

Sex: M

Age: 72

Location of Tumor/Lesions: Right Posterior Trunk

Surgeon: Murray

Images/Data of study:

Preop Images:

OR Images:

Tissue Resected:

Neoprobe

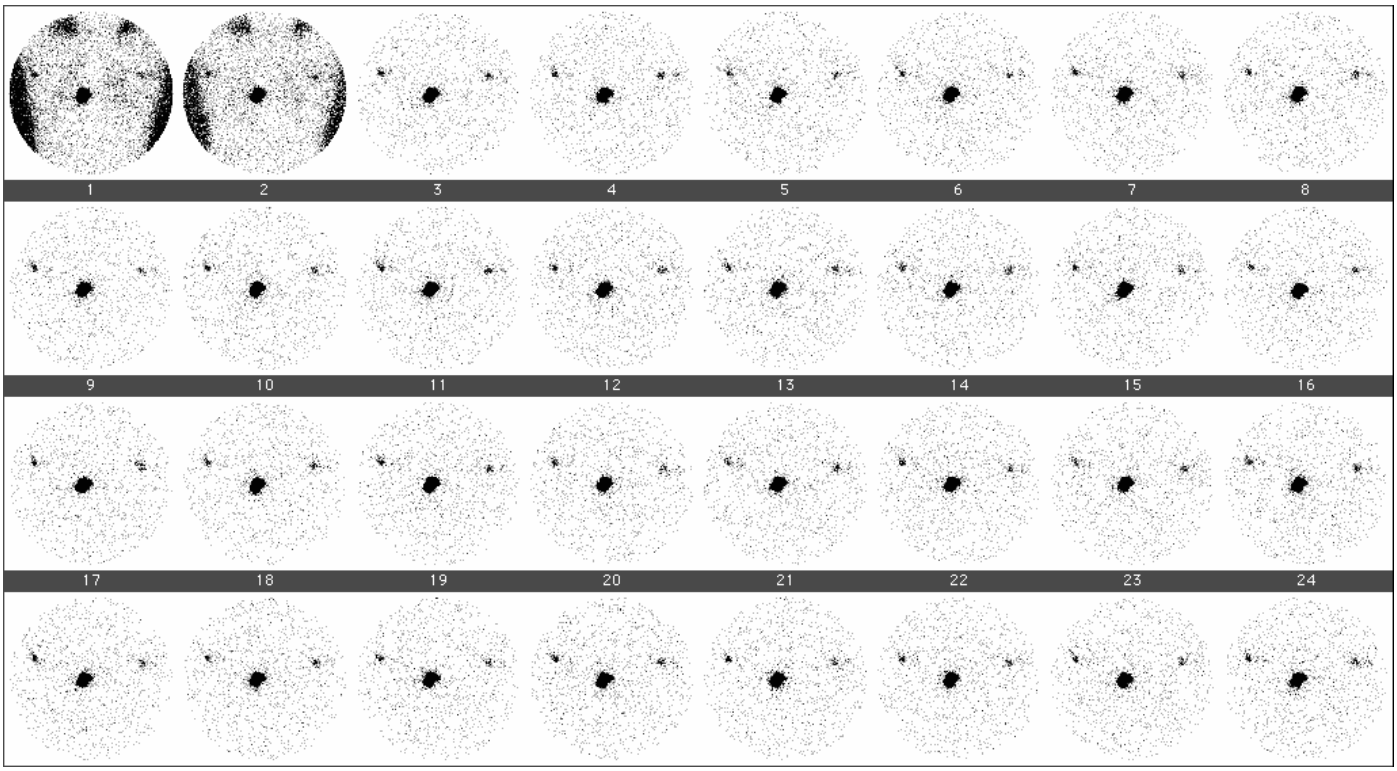
Sample ID	Indicator	Post-ex count	OR Img Activity	Location
1(SLN)	Hot/blue	12328	NA	Right axilla
2(SLN)	Hot	731	NA	Left axilla
3(SLN)	Hot	1659	NA	Left axilla

Pathology: Hot SN#1 (0/1) non-blue, Hot SN#2 (0/1) non-blue, Hot SN #3 (0/1) non-blue

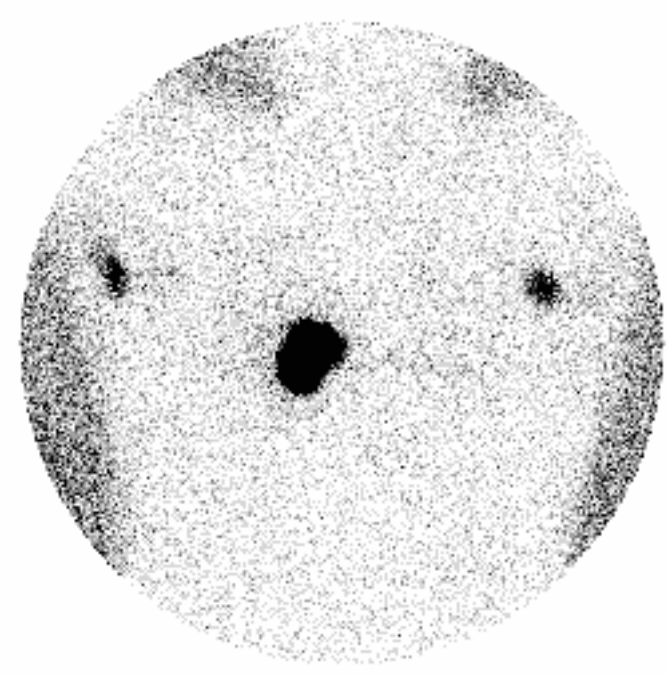
Comments/Discussion: The lesion is located on the right posterior of the trunk (Left mid peri dorsal). Patient was injected 08:55 with 0.136 mCi. and surgery started 14:30. There were no positive nodes found out of a total of 3. Margin resected measures 7.6cm long by 3.3cm wide by 2.5cm deep, Scar in center measures 0.8 x 0.6cm. There is nothing significant noted in this case.

ME01

Preoperative Images

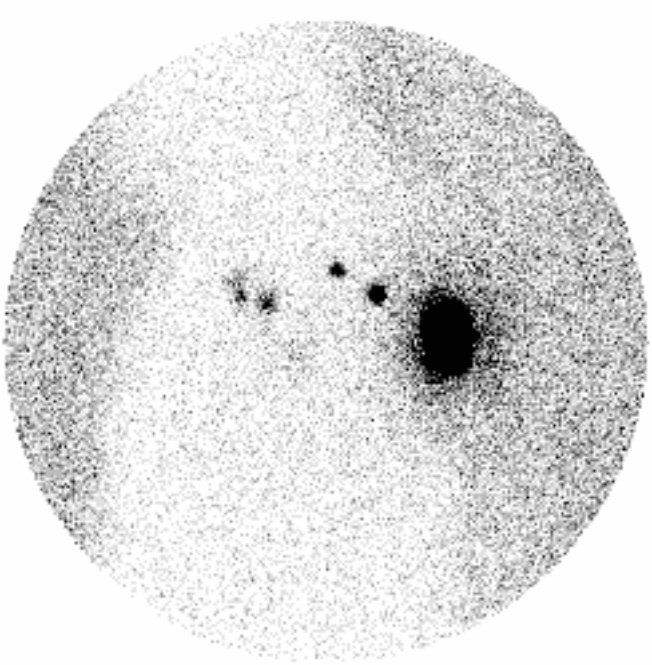


20 SEC-FRAMED FLOW

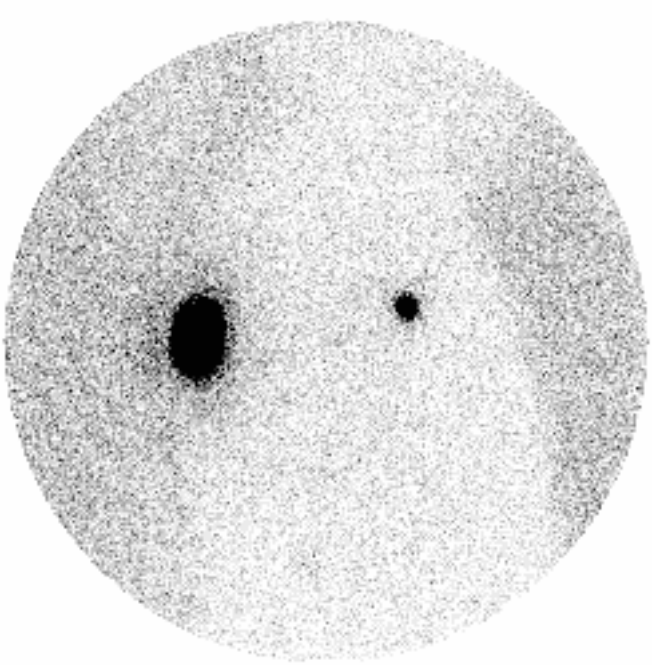


DORSAL 20MIN

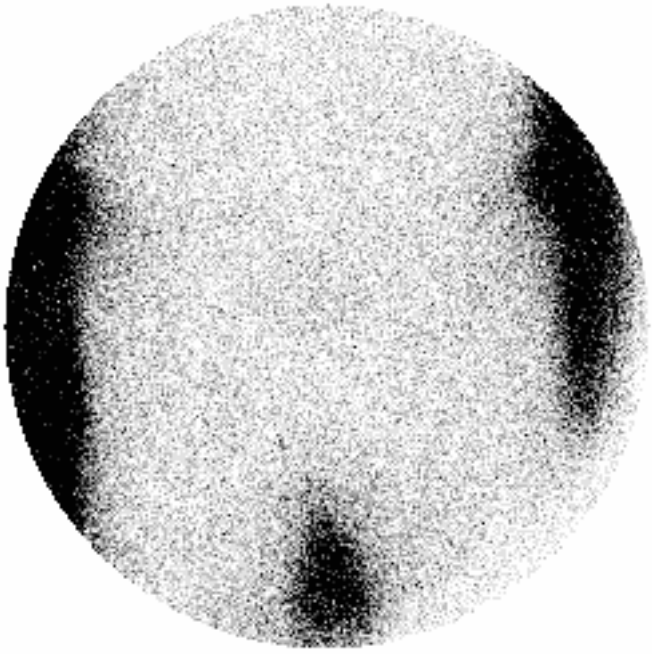
ME01



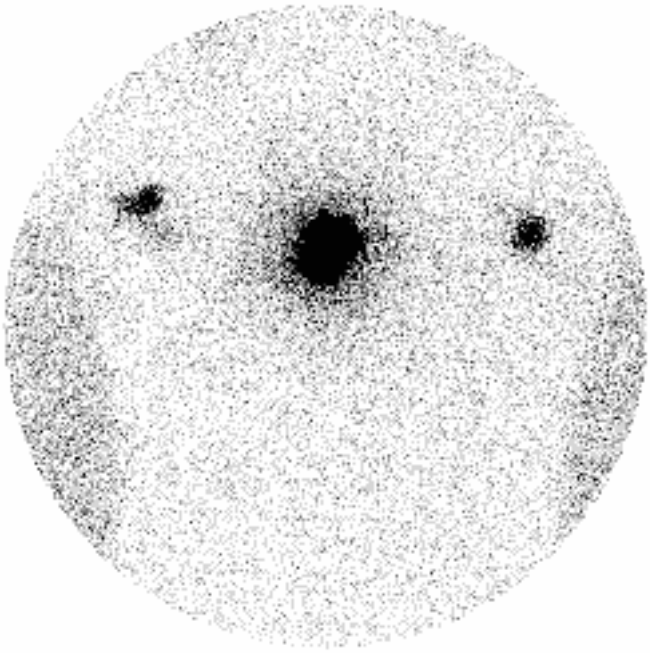
LTLAT AX 25MIN



RTLAT AX 25MIN

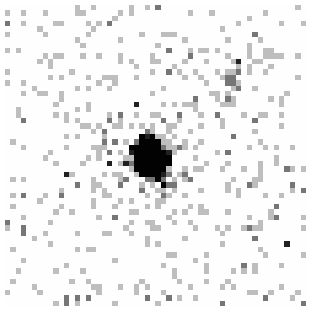


PEL 45MIN

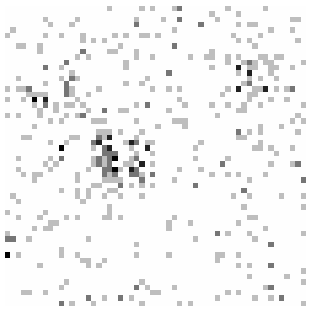


DORSAL 50MIN

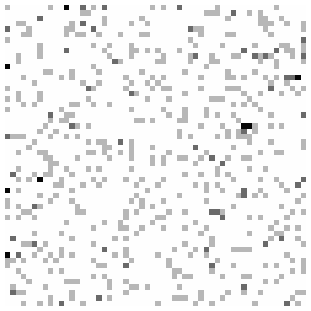
OR Images



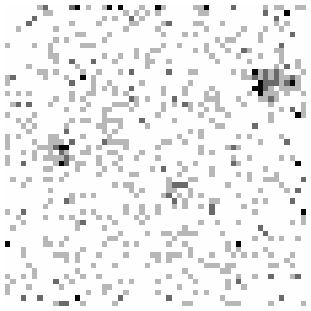
TIFF name: preinc rlat Interfile name: ME01_1
Image duration: 180 sec Start time: 13:57:35



TIFF name: preinc llat Interfile name: ME01_1
Image duration: 180 sec Start time: 14:28:20



TIFF name: postex rlat Interfile name: ME01_2
Image duration: 300 sec Start time: 15:00:22



TIFF name: postex llat Interfile name: ME01_2
Image duration: 300 sec Start time: 15:17:37

ME02

5x5 Patient: ME02

Date of Study: 01/03/02

Patient Initials: MK

Patient History:

Sex: F

Age: 42

Location of Tumor/Lesions: Abdomen to the left of midline below the umbilicus

Surgeon: Murray

Images/Data of study:

Preop Images:

OR Images:

Tissue Resected:

Neoprobe

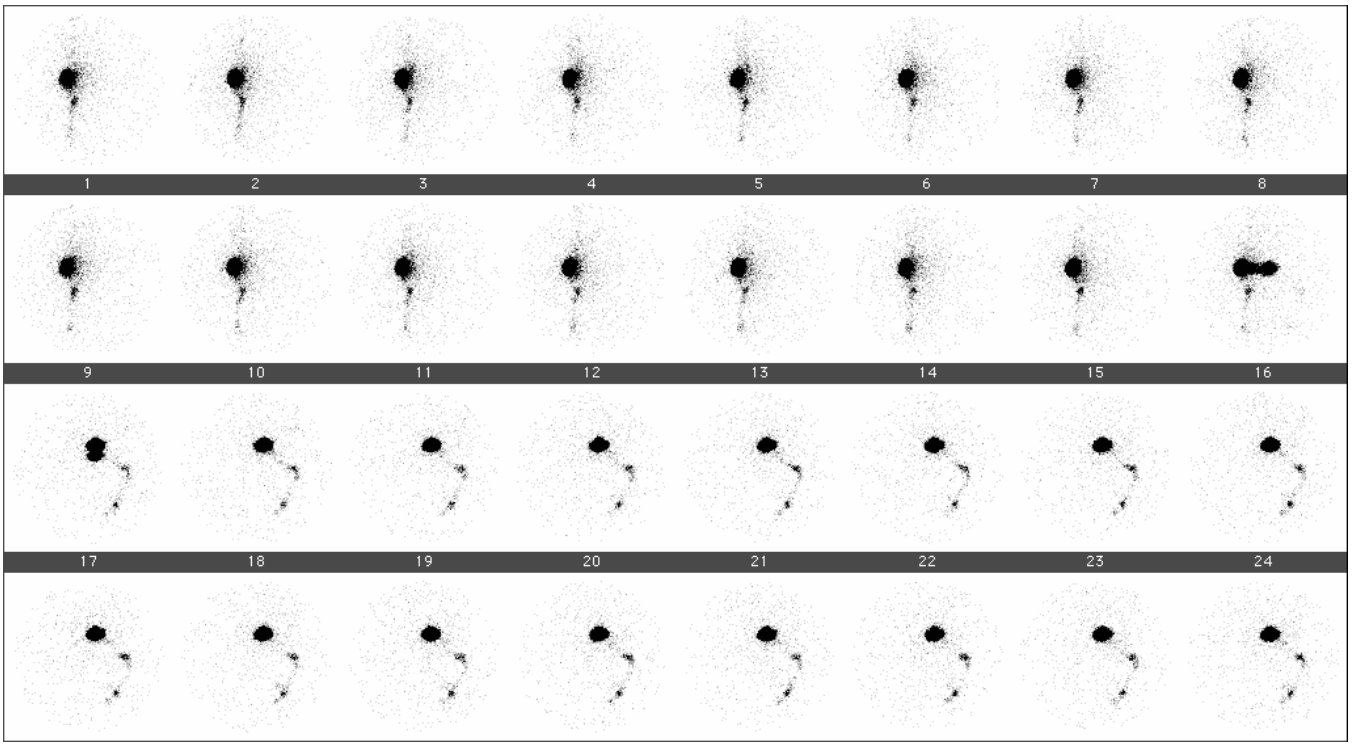
Sample ID	Indicators	Post-ex counts	OR img activity	Location
1(SLN)	Hot/blue	5561	NA	Left axilla
2(SLN)	Hot	2430	NA	Left axilla
3(SLN)	Hot/blue	10138	NA	Left inguinal
4(SLN)	Hot/blue	1917	NA	Lateral inguinal
5(SLN)	Hot	3758	NA	Left inguinal

Pathology: Hot SN #1 (0/3)no mention of blue, node size ranges 0.8-1.5 cm; Hot SN #2 (0/1) non-blue, node and tissue measures 1.5 x 1.0 x 0.5cm; Hot SN #3 (0/1) blue, node and tissue measures 2.0 x 1.0 x 0.5 cm, node diameter measures 1.7 cm; Hot SN #4 (0/1) blue, node and tissue measures 3.2 x 1.5 x 0.5cm, node measures 1.0 cm in diameter; Hot SN #5 (0/1) non-blue, node and tissue measures 3.2 x 1.5 x 0.5 cm and node measures 1.0 cm in diameter.

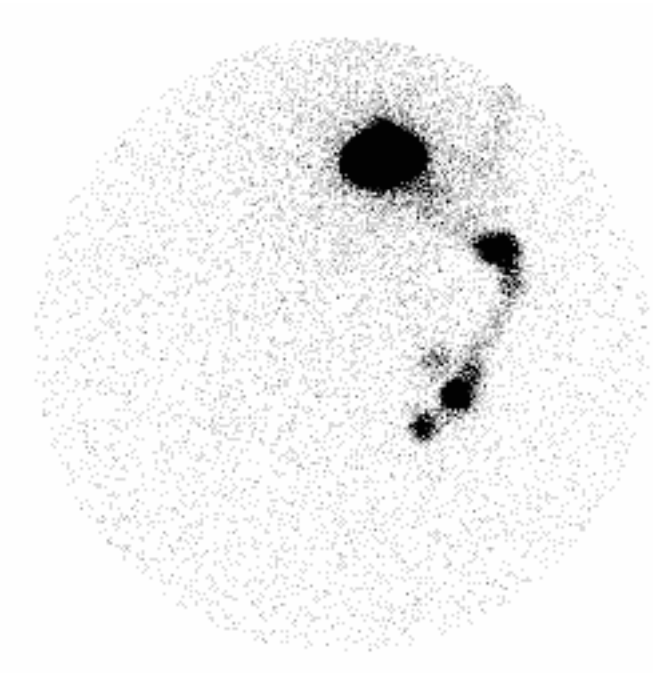
Comments/Discussion: The lesion is located on the left of the abdomen below the umbilical area (Left peri-umbilical melanoma). The patient was injected at 10:20 with 0.159 mCi of Tc-sulfur colliod. Surgery began at 16:00. There were no positive nodes found out of a total of 7 nodes. The margin resected measured 5.0 x 3.0 x 3.0cm. The scar in the excision measures 1.0cm. There are no significant notes to document on this case.

ME02

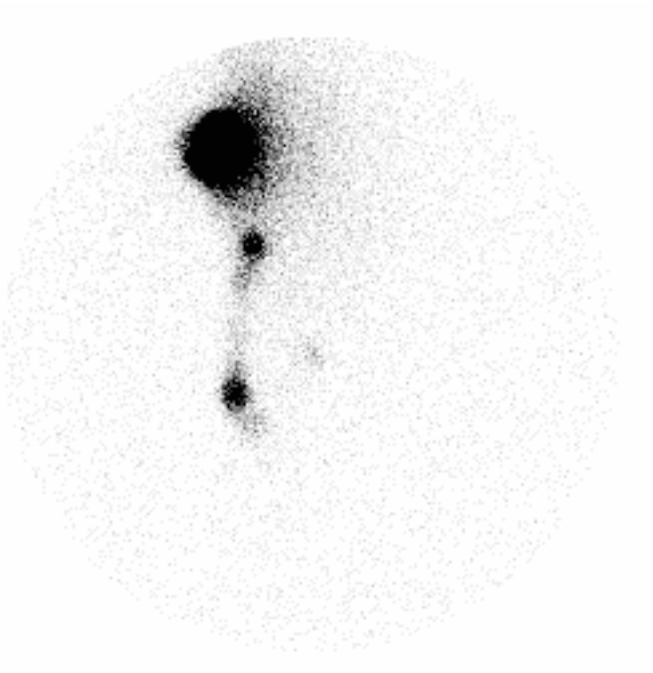
Preoperative Images



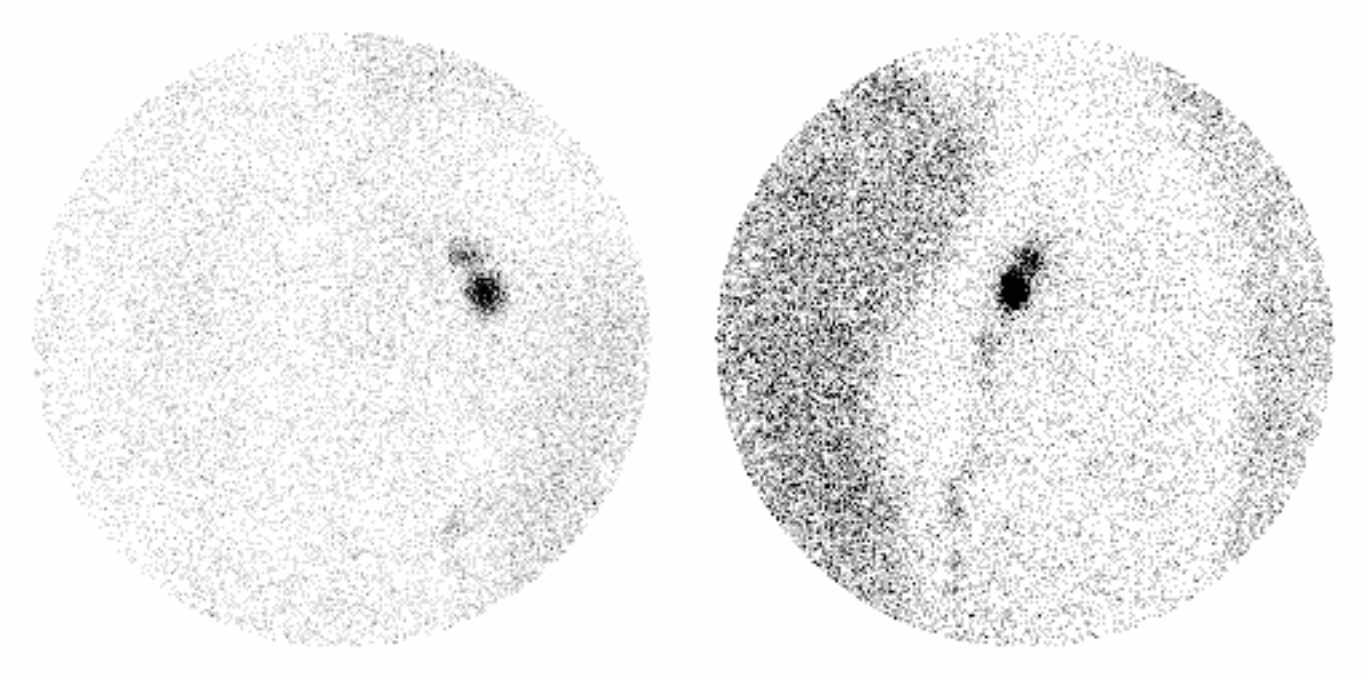
20 SEC-FRAMED FLOW



ANTPEL 15MIN

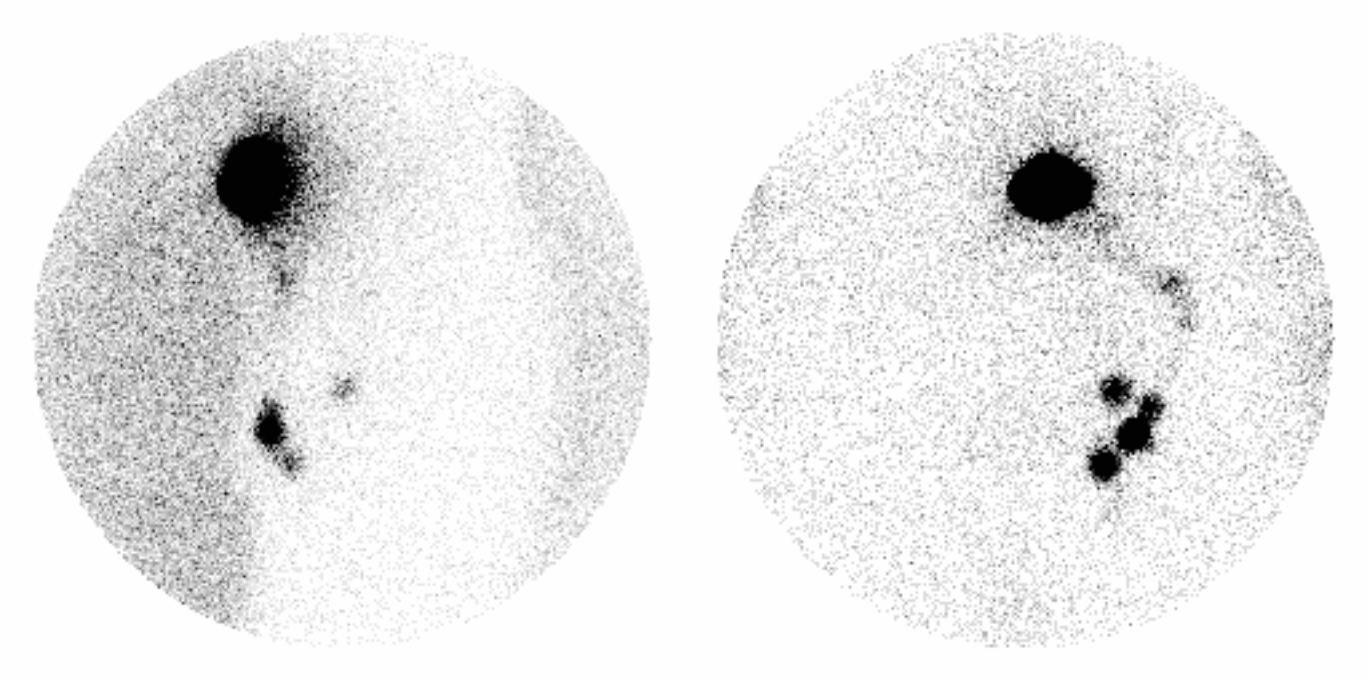


LTLATPEL 20MIN



ANTCHEST 25MIN

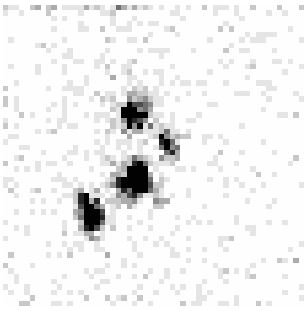
LTLATPCHEST 30MIN



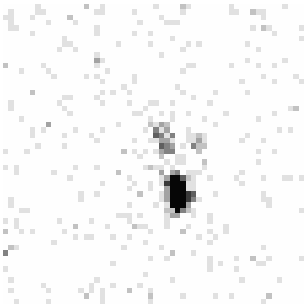
LTLATPEL 35MIN

ANTPEL 45MIN

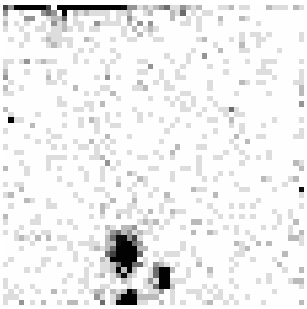
OR Images



TIFF name: ant pelvis1 Interfile name: ME02_1
Image duration: 180 sec Start time: 15:44:15

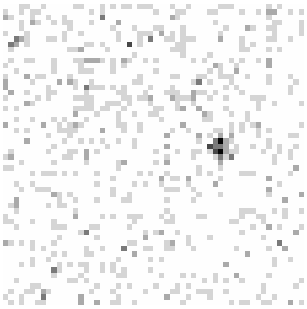


TIFF name: lao45 ax Interfile name: ME02_2
Image duration: 120 sec Start time: 15:49:01



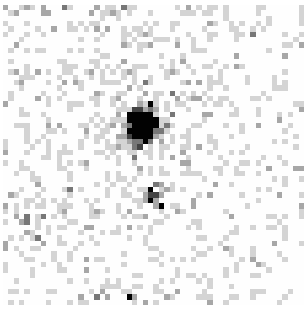
TIFF name: ant pelvis2 Interfile name: ME02_3
Image duration: 240 sec Start time: 15:53:27

Attempt to get injection site into picture…



TIFF name: lao45 ax postex Interfile name: ME02_4
Image duration: 300 sec Start time: 16:52:08

ME02



TIFF name: ant pelvis postex Interfile name: ME02_5
Image duration: 300 sec Start time: 17:31:02

Deep focus (#4) not excised (see lateral preop image)

ME03

5x5 Patient: ME03

Date of Study: 01/03/02

Patient Initials: PR

Patient History:

Sex: F

Age: 55

Location of Tumor/Lesions: Right upper arm

Surgeon: Murray

Images/Data of study:

Preop Images:

OR Images:

Tissue Resected:

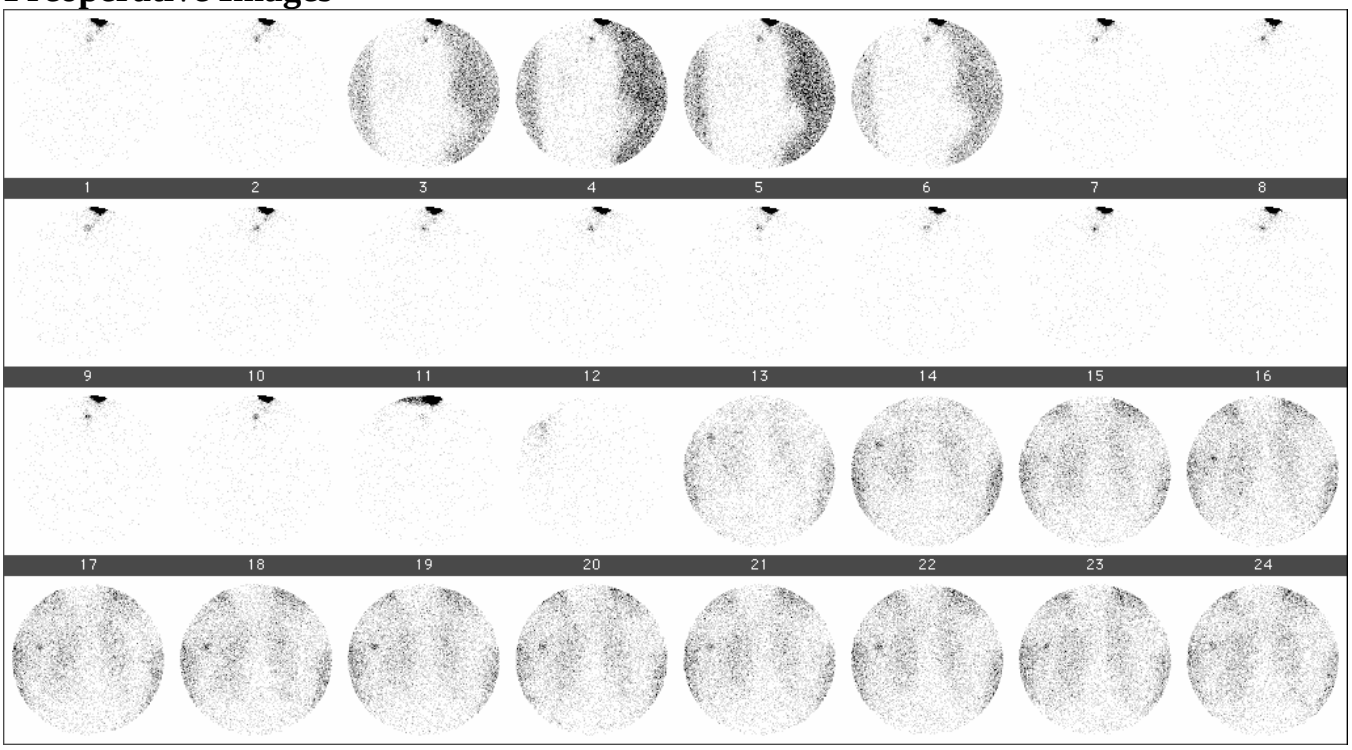
Neoprobe

Sample ID	Indicators	Post-ex Counts	OR Image Activity	Location
1(NonSLN)	Blue	No counts	71	Right axilla
2(SLN)	Blue/hot	5921	1118	Right axilla
3(SLN)	Hot	548	45	Right axilla
4(SLN)	Hot	423	42	Right axilla

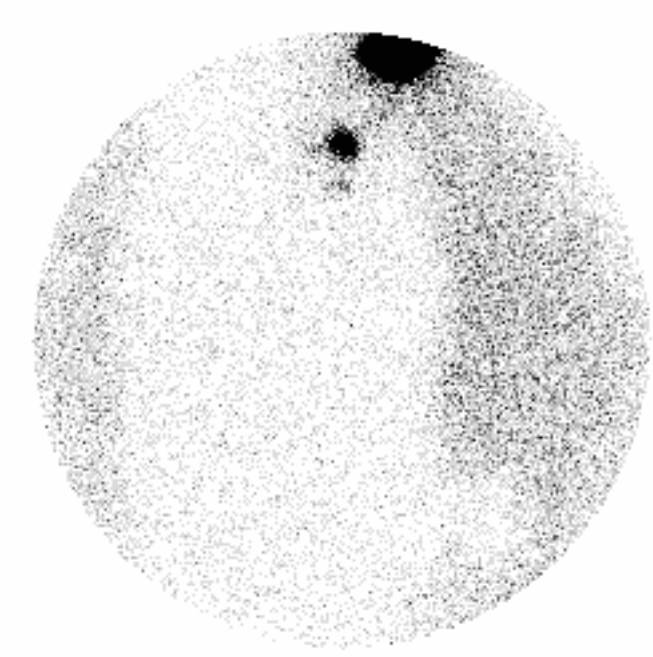
Pathology: Hot SN #1(0/1) blue, node and adipose tissue measures 1.9 x 1.4 x 0.5 cm; Hot SN #2 (0/1) non-blue, node and tissue measures 2.5 x 1.0 x 0.5 cm; Hot SN #3 (0/1) non-blue, 1.0 x 0.5 x 0.5 cm.

Comments/Discussion: The lesion is located on the right upper arm(right upper extremity). The patient was injected with 0.167mCi of Tc99m sulfur colloid at 12:10. Surgery began at 17:55. There were zero positive nodes found out of 3 SN. The resected tissue has a raised scar 0.9 x 0.8cm in size. There are no significant points to note about this case.

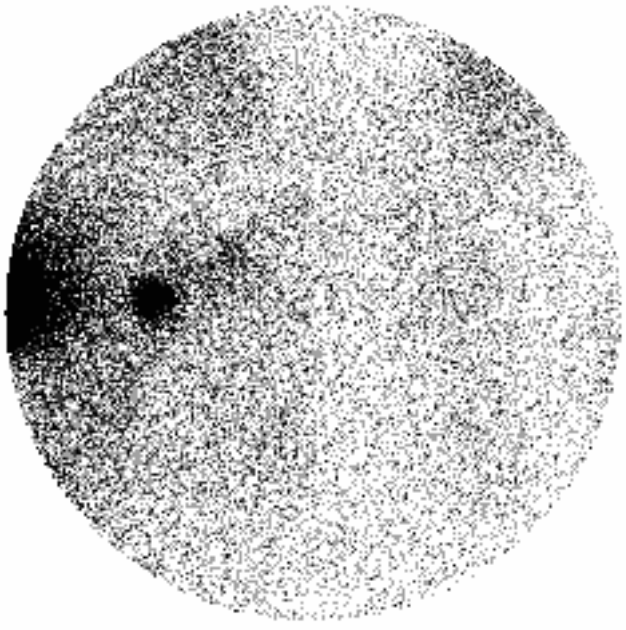
Preoperative Images



20 SEC-FRAMED FLOW

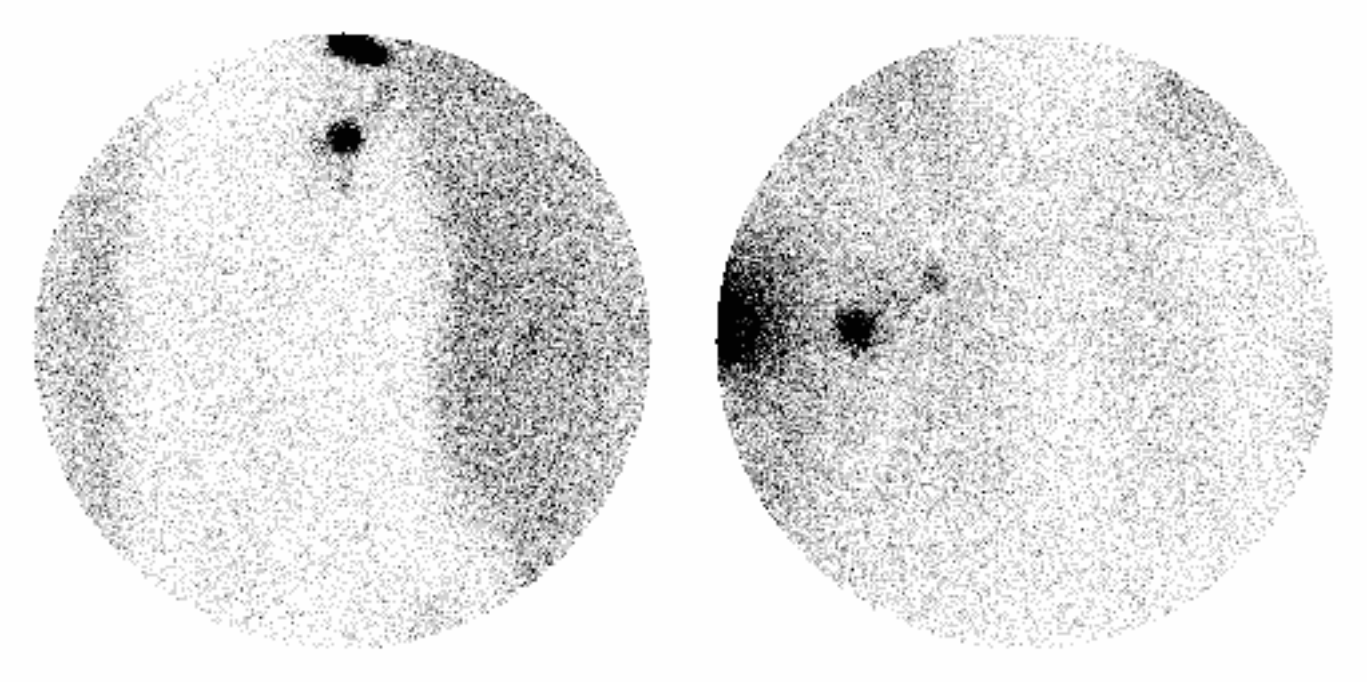


RTLAT 15MIN



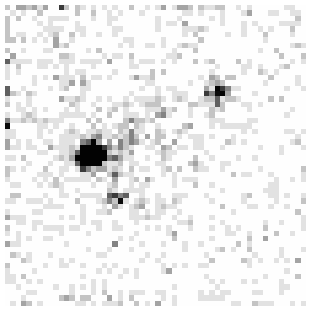
ANT 20MIN

ME03

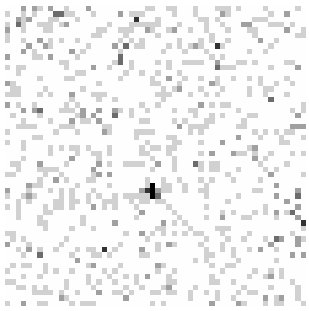


RTLAT 30MIN **ANT 35MIN**

OR Images

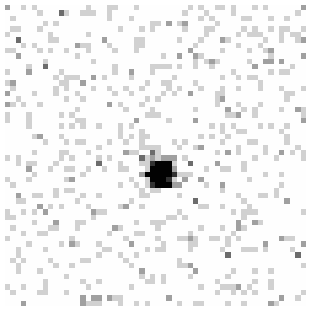


TIFF name: rao30 ax Interfile name: ME03_4
Image duration: 300 sec Start time: 18:01:19

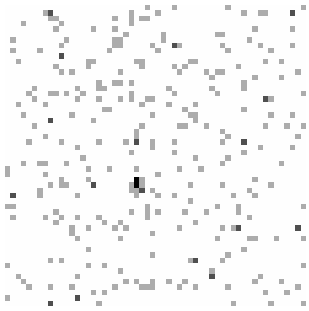


TIFF name: non-sn Interfile name: ME03_5
Image duration: 300 sec Start time: 18:17:09

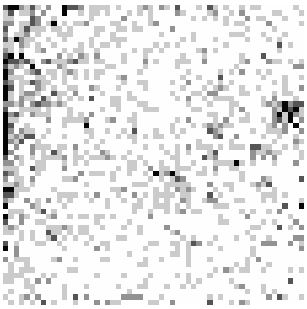
Surgeon thought no probe counts, but…



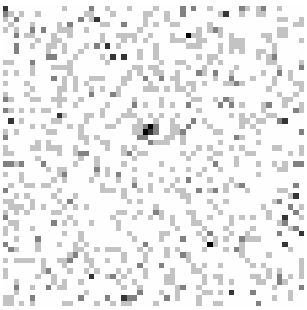
TIFF name: node1 Interfile name: ME03_5
Image duration: 240 sec Start time: 18:23:14



TIFF name: node2 Interfile name: ME03_1
Image duration: 120 sec Start time: 18:36:01



TIFF name: rao30 ax postex Interfile name: ME03_2
Image duration: 300 sec Start time: 18:42:08



TIFF name: node3 Interfile name: ME03_3
Image duration: 300 sec Start time: 18:49:05

ME04

5x5 Patient: Date of Study: ME04

Patient Initials: TH

Patient History:

Sex: F

Age: 56

Location of Tumor/Lesions: Right forearm

Surgeon: Murray

Images/Data of study:

Preop Images: GE 400 Emory nuclear med staff

OR Images: 5 x 5 gamma camera

Tissue Resected:

Neoprobe

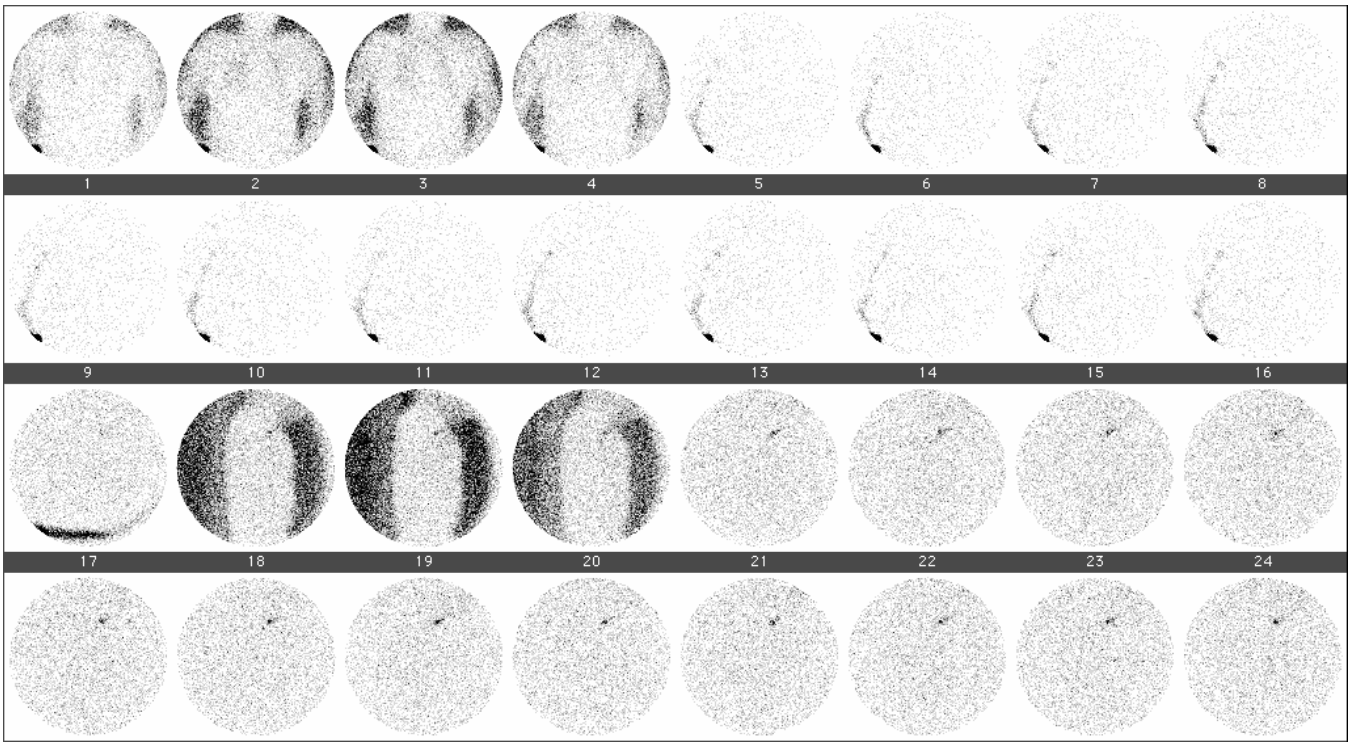
Sample ID	Indicators	Post-ex Counts	OR Image Activity	Location
1(SLN)	Hot	899	118	Right axilla
2(SLN)	Hot	2831	849	Right axilla
3(SLN)	Hot	1754	183	Right axilla

Pathology: Hot SN #1 (0/1) no mention of blue dye, node and adipose tissue measures 2.5 x 1.5 x 1.0 cm; Hot SN #2 (0/1) no mention of blue dye, node and tissue measures 1.5 x 1.5 x 0.5 cm; Hot SN #3 (0/1) no mention of blue dye, node and tissue measures 1.0 x 0.8 x 0.5 cm.

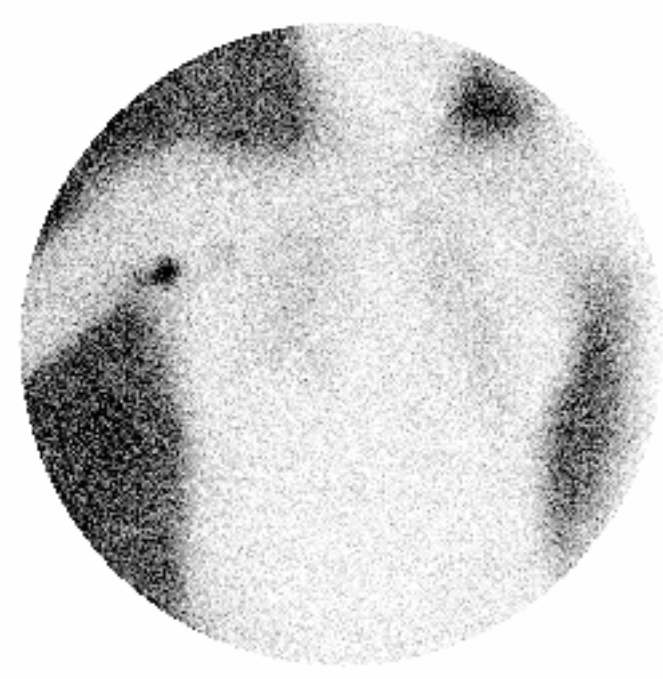
Comments/Discussion: The lesion is located on the right forearm (mid dorsal right forearm). The patient was injected at 9:05 with 0.152mCi of Tc99m sulfur colloid. Surgery began at 16:35 hours. There were no positive nodes of 3 sent for pathology. The scar found on the excised tissue was 0.7cm in size. There was nothing significant to record about this case.

ME04

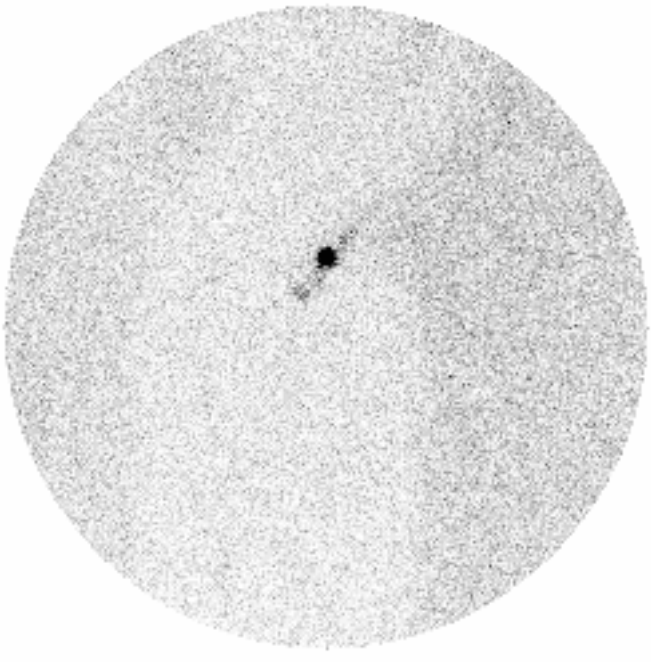
Preoperative Images



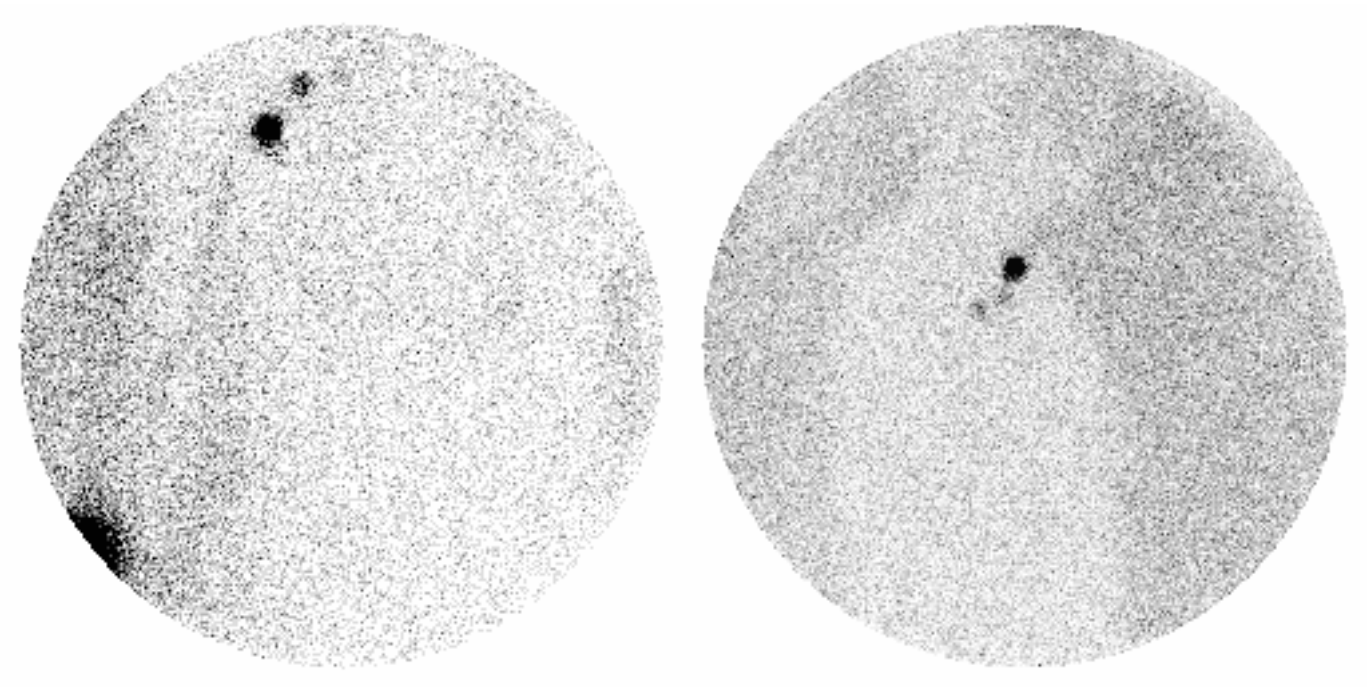
20 SEC-FRAMED FLOW



ANT 15MIN

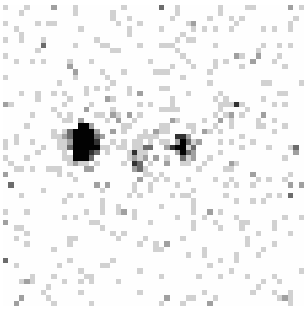


RTLAT 20MIN

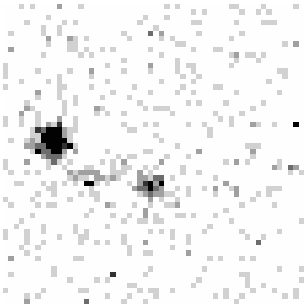


ANT 30MIN **RTLAT 40MIN**

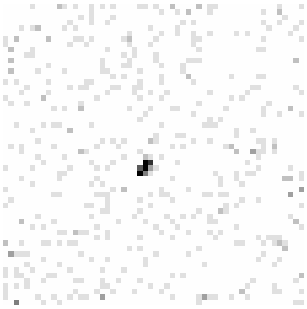
OR Images



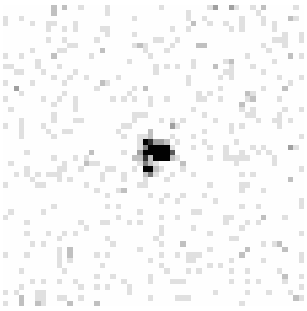
TIFF name: rao ax Interfile name: ME04_1
Image duration: 180 sec Start time: 16:06:02



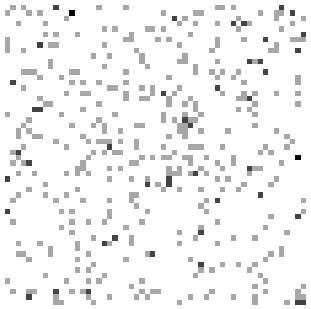
TIFF name: ant ax Interfile name: ME04_1
Image duration: 180 sec Start time: 16:10:22



TIFF name: node1 Interfile name: ME04_2
Image duration: 180 sec Start time: 16:48:05

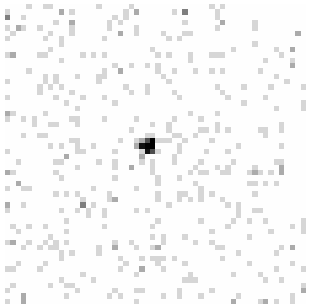


TIFF name: node2 Interfile name: ME04_2
Image duration: 180 sec Start time: 17:00:09



TIFF name: rao ax postex Interfile name: ME04_3
Image duration: 180 sec Start time: 17:15:46

Camera positioning altered from that in “rao ax”… but we can’t tell that here.



TIFF name: node3 Interfile name: ME04_4
Image duration: 180 sec Start time: 17:20:19

ME05

5x5 Patient: ME05

Date of Study: 01/28/02

Patient Initials: PW

Patient History:

Sex: M

Age: 51

Location of Tumor/Lesions: Base of posterior neck, slightly left of midline

Surgeon: Murray

Images/Data of study:

Preop Images: GE 400 Emory nuclear med staff

OR Images: 5 x 5 gamma camera

Tissue Resected:

Neoprobe

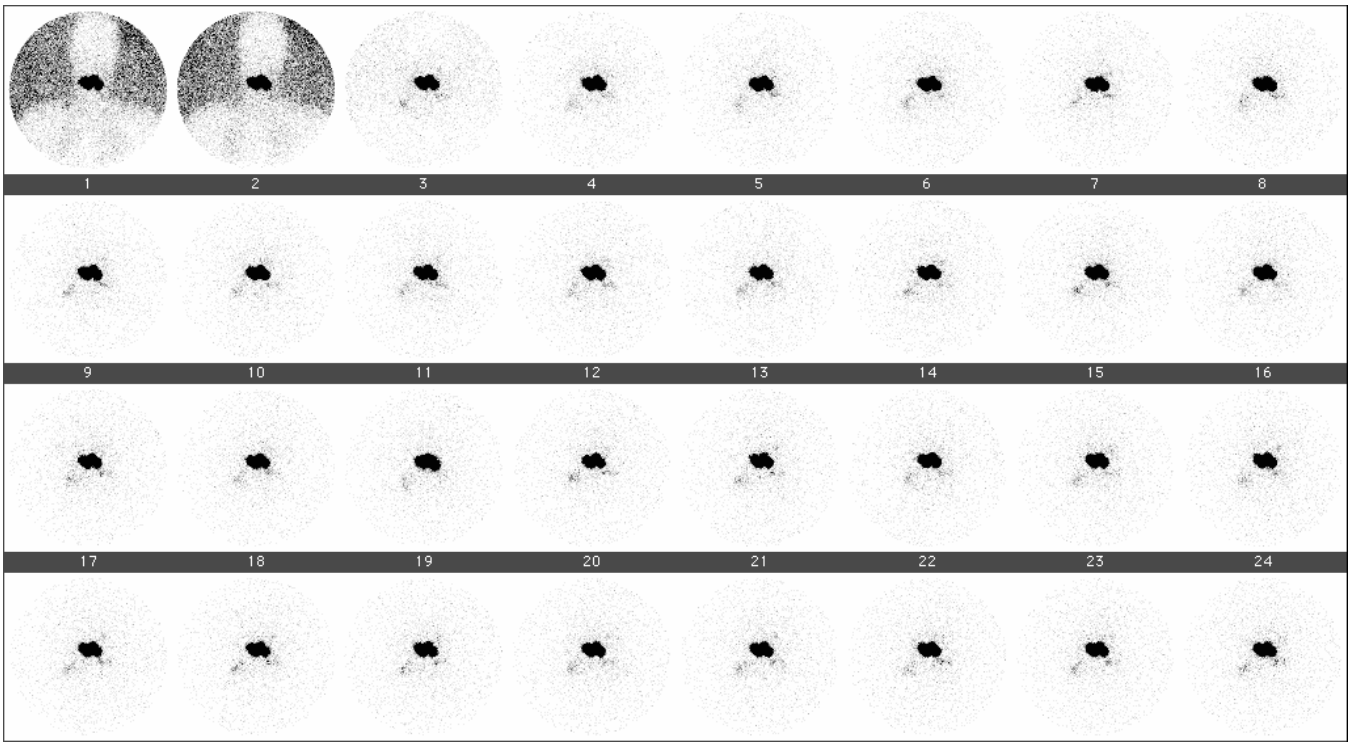
Sample ID	Indicators	Post-ex Counts	OR Image Activity	Location
1(SLN)	Hot	939	358	Left neck
2(SLN)	Hot	3662	438	Left neck
3(SLN)	Hot	1397	209	Left neck
4(SLN)	Hot	642	195	Left Medial
5(SLN)	Hot	1057	139	Left Medial
6(SLN)	Hot	879	187	Right neck

Pathology: There was no mention of blue dye for any of the lymph nodes examined. Hot SN #1(0/1), node and tissue measures 2.5 x 1.2 x 0.5 cm; Hot SN #2 (0/1), node measures 0.3 cm in greatest dimension; Hot SN #3 (0/1), tissue and node measures 1.5 x 0.7 x 0.5 cm; Hot SN #4 (0/1), tissue and node measures 1.7 x 0.7 x 0.6 cm; Hot SN #5 (0/1), tissue and node measures 0.9 x 0.5 x 0.5 cm; Hot SN #6 (0/1), tissue and node measures 2.5 x 1.5 x 1 cm .

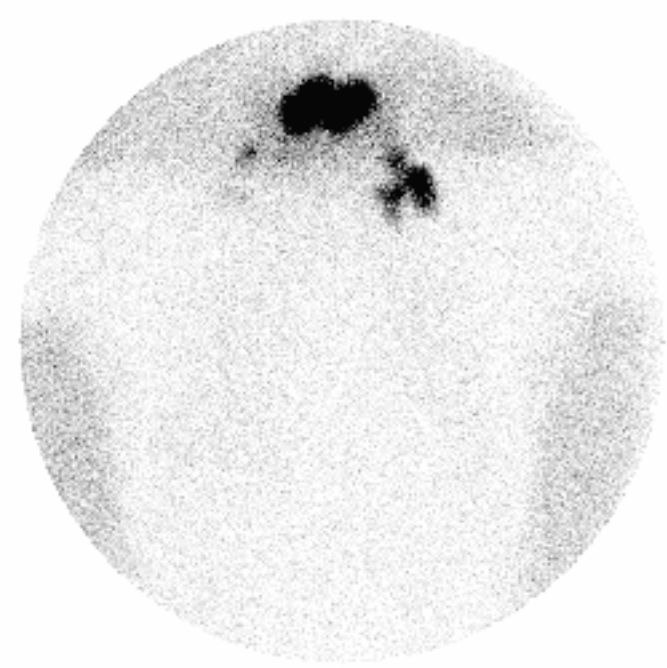
Comments/Discussion: The lesion was located on the posterior base of the neck slightly left of the mid line. The patient was injected with 0.162 mCi of Tc99m sulfur colloid at the 10:45 hour. Surgery began at 19:00 hours. There were no positive nodes found in any of 6 nodes examined. The scar centered in the wide excised tissue measured 2 x0.1cm. This patient also had a previous biopsy on back of lower left thigh. There was nothing else significant to be noted about this case.

ME05

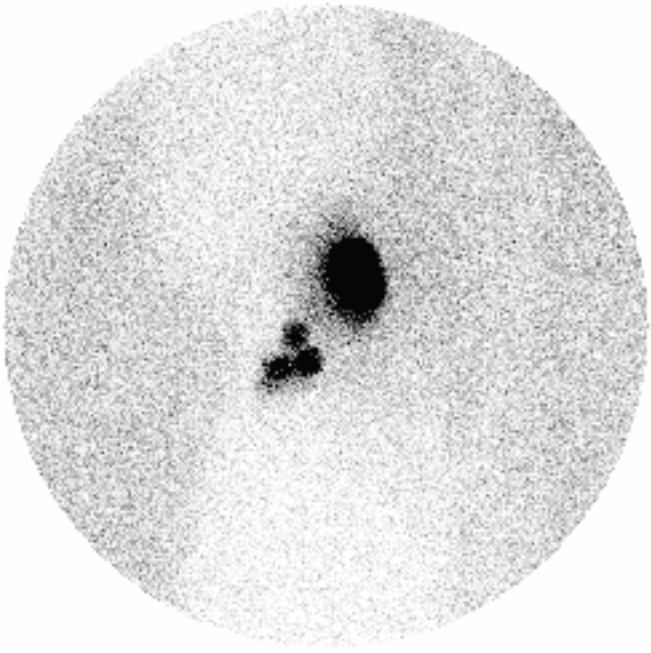
Preoperative Images



20 SEC-FRAMED FLOW

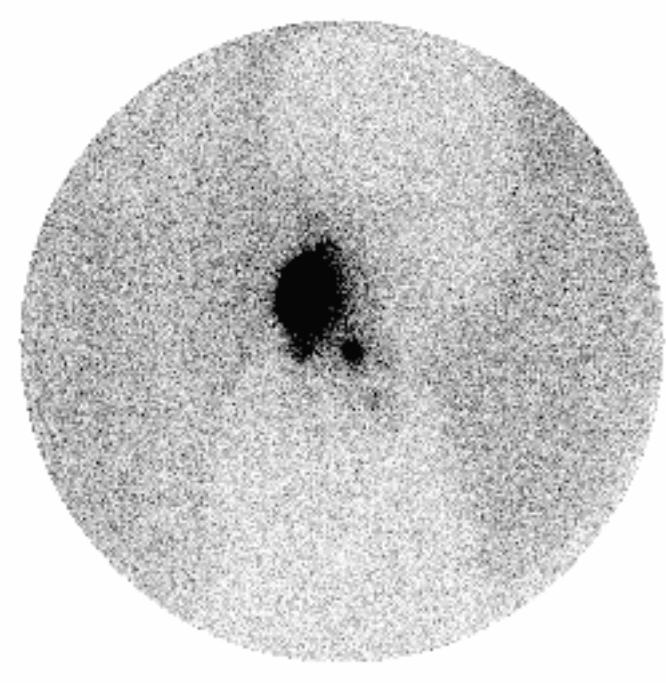


ANT 15MIN

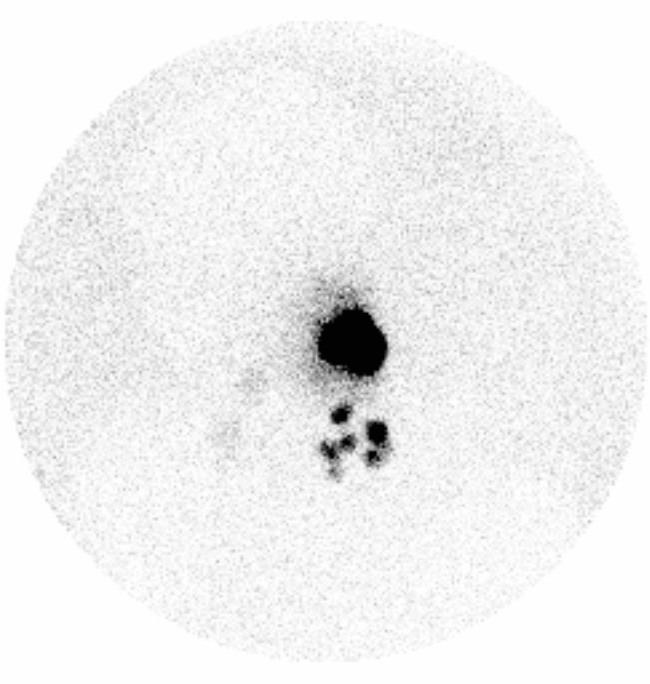


LTLAT 20MIN

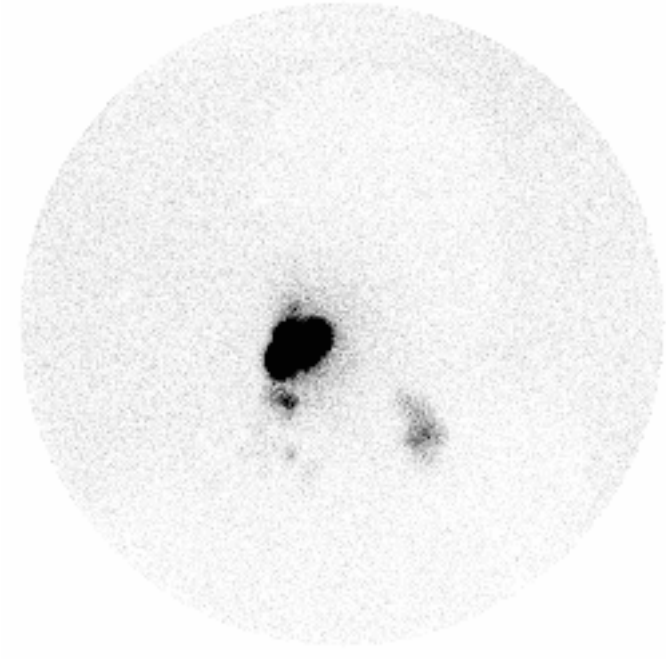
ME05



RTLAT 30MIN

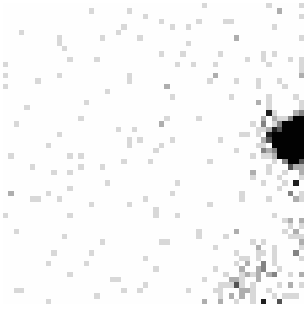


LAO 35MIN

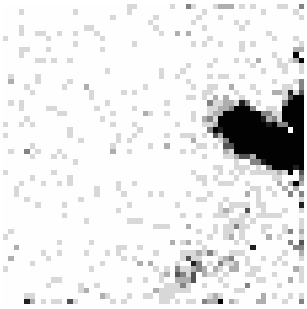


RAO 45MIN

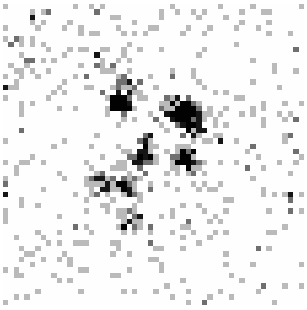
OR Images



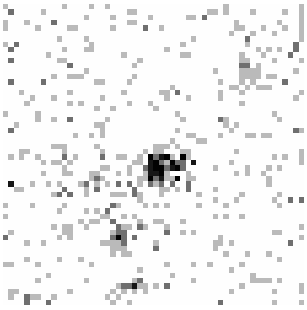
TIFF name: left post1 Interfile name: ME05_1
Image duration: 56 sec Start time: 18:58:36



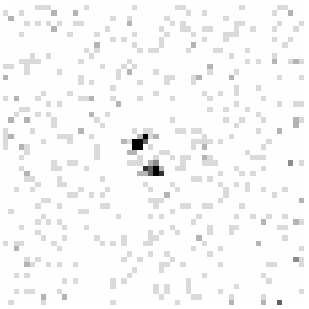
TIFF name: left post2 Interfile name: ME05_1
Image duration: 113 sec Start time: 18:59:59



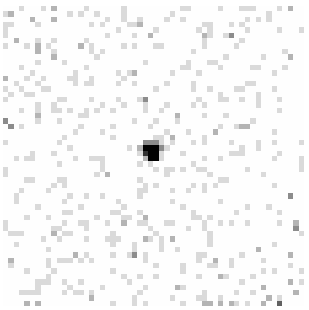
TIFF name: lao45 neck Interfile name: ME05_2
Image duration: 149 sec Start time: 19:59:35



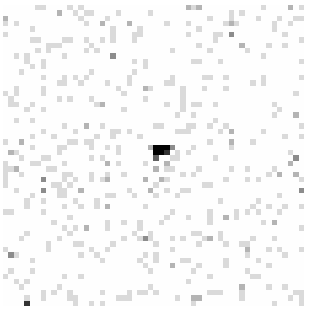
TIFF name: rao neck Interfile name: ME05_2
Image duration: 154 sec Start time: 20:04:01



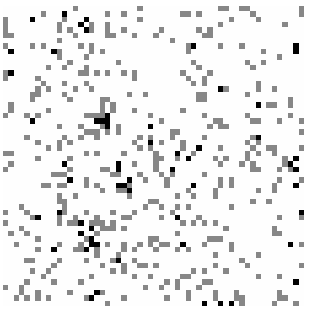
TIFF name: node1 Interfile name: ME05_3
Image duration: 180 sec Start time: 20:48:57



TIFF name: node2 Interfile name: ME05_3
Image duration: 180 sec Start time: 20:52:27

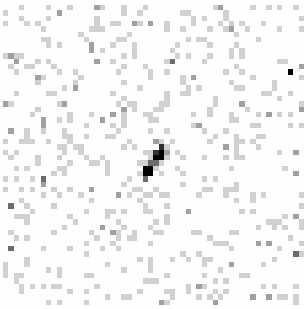


TIFF name: node3 Interfile name: ME05_3
Image duration: 180 sec Start time: 20:58:19

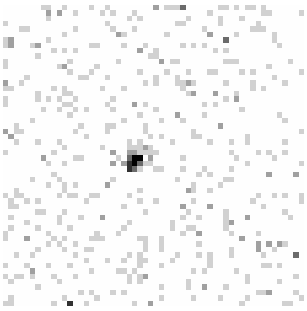


TIFF name: lao45 neck postex Interfile name: ME05_4
Image duration: 180 sec Start time: 21:17:02

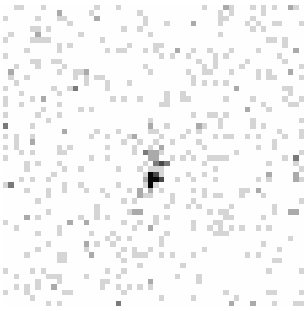
ME05



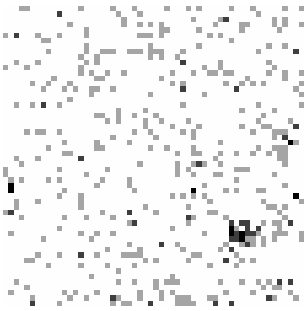
TIFF name: node4 Interfile name: ME05_5
Image duration: 180 sec Start time: 21:21:58



TIFF name: node5 Interfile name: ME05_5
Image duration: 180 sec Start time: 21:27:11



TIFF name: node6 Interfile name: ME05_6
Image duration: 180 sec Start time: 21:48:20



TIFF name: rao neck postex Interfile name: ME05_7
Image duration: 180 sec Start time: 21:57:57

ME06

5x5 Patient: ME06

Date of Study: 06/05/03

Patient Initials: RJ

Patient History: Skin right forearm melanoma.

Sex: Male

Age: 71

Location of Tumor/Lesions: Right forearm

Breslow thickness 2.50 mm

Clark level at least IV

Surgeon: Murray

Images/Data of study:

Preop Images: GE 400 Emory nuclear med staff

OR Images: 5 x 5 gamma camera

Tissue Resected:

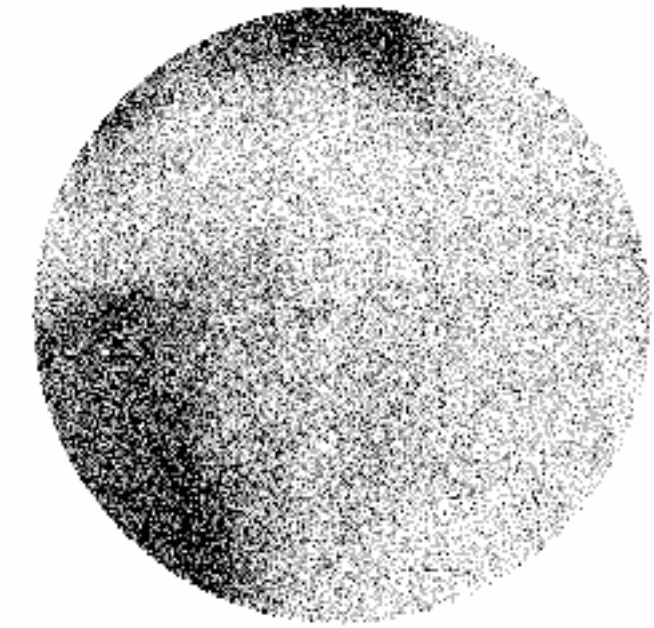
Neoprobe

Preop focus	Sample ID	Indicator	Post-ex count	OR Img Activity	Location
1	1	Hot	644	247	Right axilla

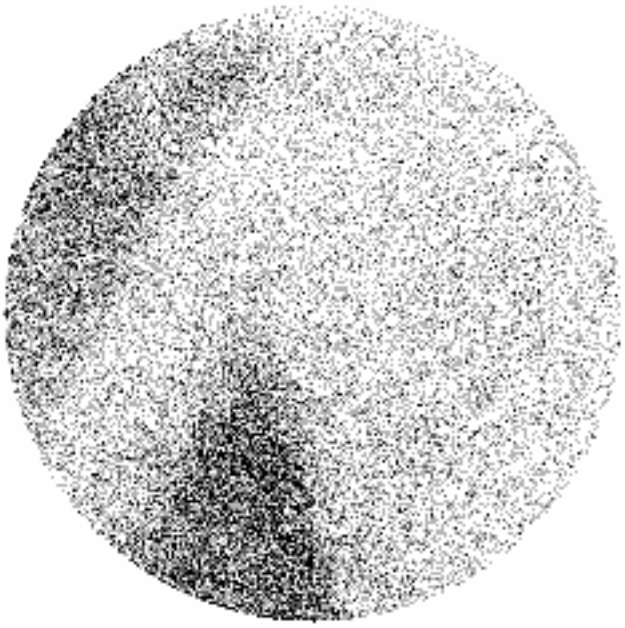
Pathology: No mention of blue dye. Hot SN #1 (0/1), node measures 3.0 x 1.5 x 0.9 cm.

Comments/ Discussion: The melanoma is located on the right forearm (proximal radial right forearm at elbow), stage II and was measured to be 2.58mm by outside report. The patient was injected with 0.233 mCi of Tc99m sulfur colloid at 9:00. Surgery began at 12:30. The sentinel node was not positive and it measured about 1.25cm . There was nothing to significant to report about this case.

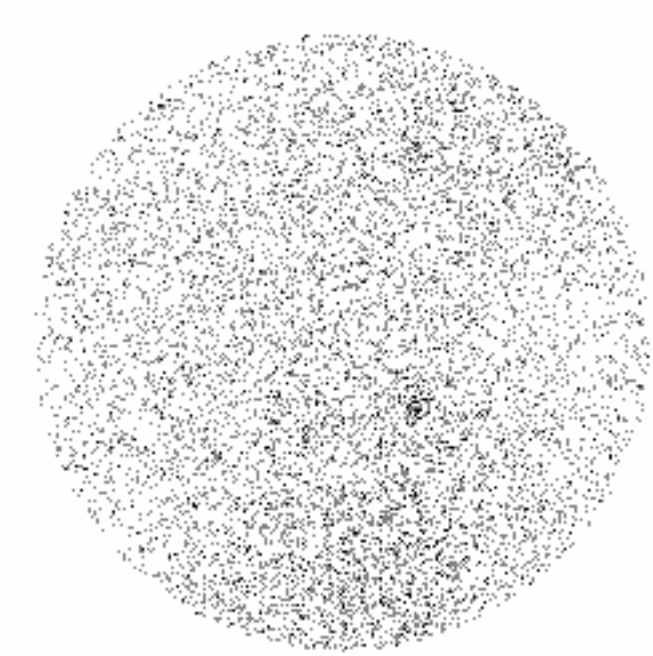
Preoperative Images



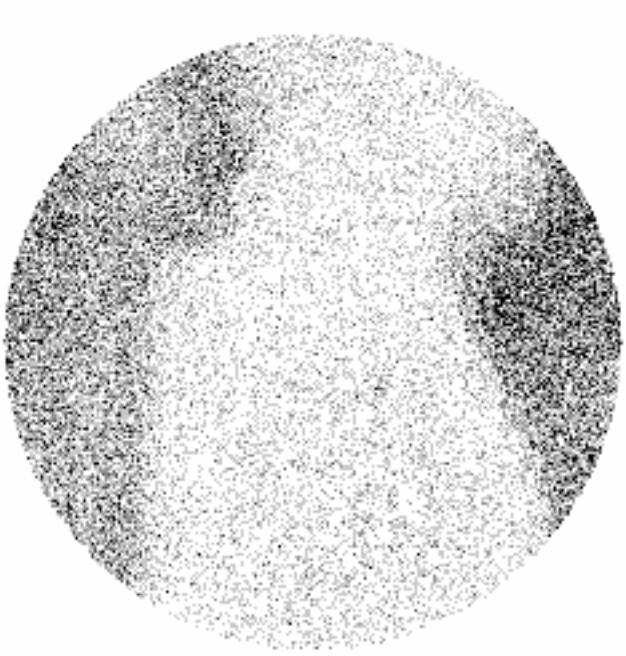
RAO 25MIN



RTANT 20MIN

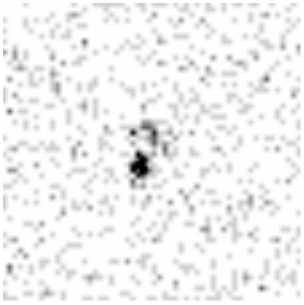


RTLATAX

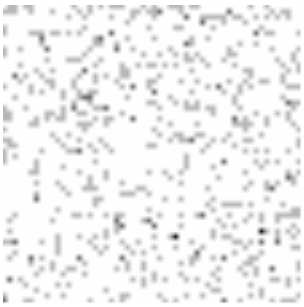


RTLATAX 40MIN

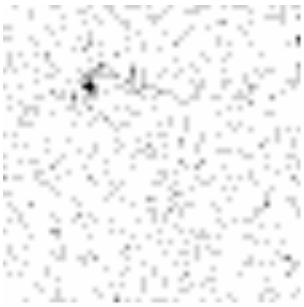
OR Images



TIFF name: preincision Interfile name: ME0
Image duration: 238 sec Start time: 12:07:34



TIFF name: postexcision Interfile name: ME0
Image duration: 239 sec Start time: 12:34:33



TIFF name: excised node Interfile name: ME
Image duration: 299 sec Start time: 12:40:26

ME07

5x5 Patient: ME07

Date of Study: 06/05/03

Patient Initials: LC

Patient History:

Sex: F

Age: 39

Location of Tumor/Lesions: Left lower back

Surgeon: Murray

Images/Data of study:

Preop Images: GE 400 Emory nuclear med staff

OR Images: 5 x 5 gamma camera

Tissue Resected:

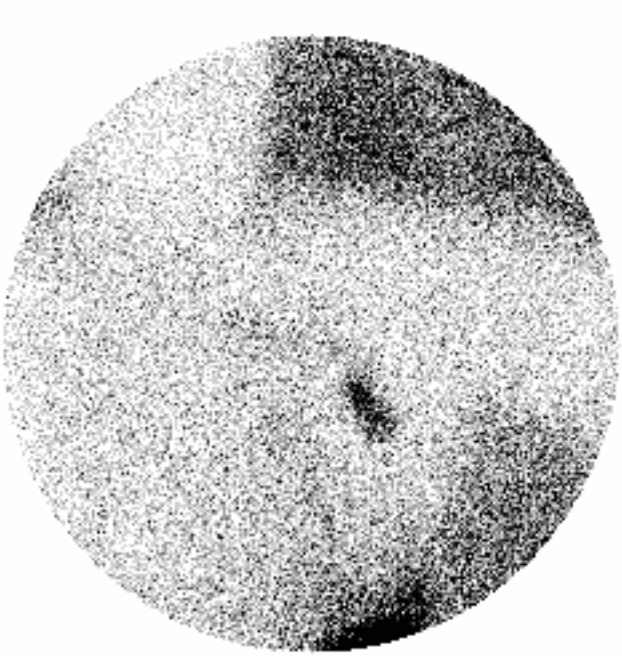
Neoprobe

Sample ID	Indicator	Post-ex count	OR Img Activity	Location
1	Hot	5187	1269	Left axilla-lateral
2	Hot	1978	339	Left axilla –mid
3	Hot	2219	1740	Axilla-medial

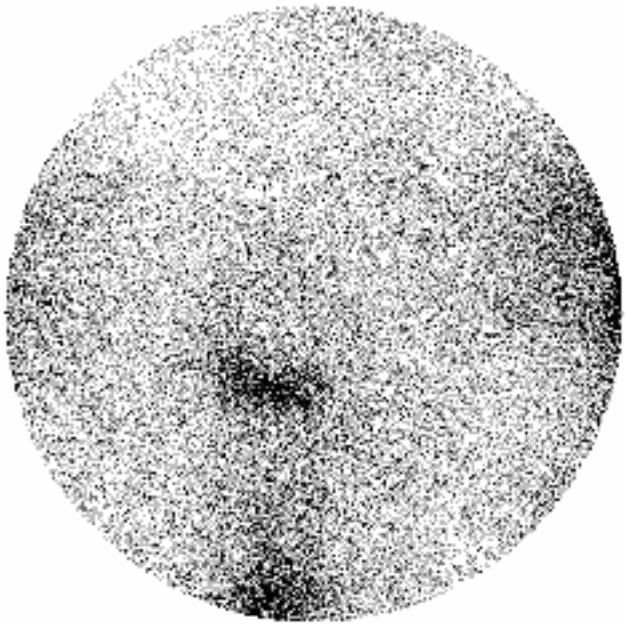
Pathology: Hot SN #1 (0/1), non-blue, node & tissue measures 3.7 x 2.9 x 0.5cm; Hot SN #2 (0/1), non-blue, node & tissue measures 2.7 x 2.6 x 0.7cm; Hot SN #3 (0/1), non-blue, node & tissue measures 3.0 x 3.0 x 0.7.

Comments/Discussion: The melanoma is located on the lower left lateral back and measures 0.95mm (by outside report). The patient was injected at 10:45 with 0.244 mCi of radiocolloid. Surgery began at 15:45 hours. There were no positive nodes out of a total of 3 sentinel nodes. There was nothing significant to note about this patient.

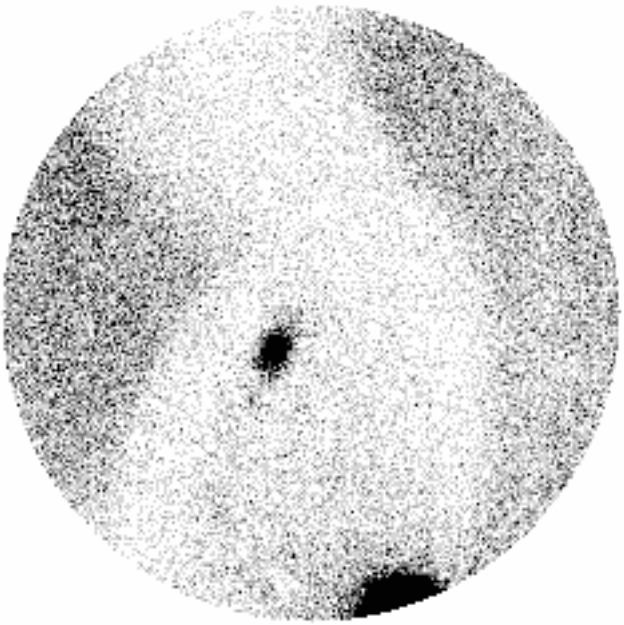
Preoperative Images



ANTLT 15MIN

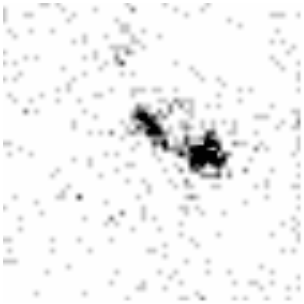


ANTPEL 20MIN

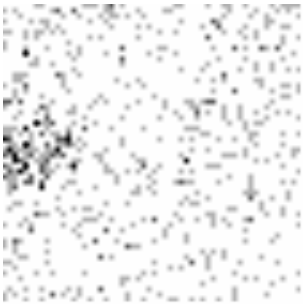


LTLATAX 25MIN

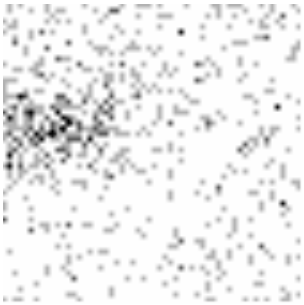
OR Images



TIFF name: Preinc Ant Interfile name: ME07
Image duration: 62.46 sec Start time: 14:24:29

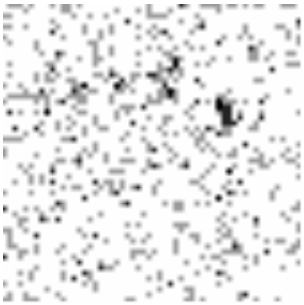


TIFF name: Preinc Inguenal Ant Interfile name: ME07
Image duration: 179.94 sec Start time: 15:22:41



TIFF name: Preinc Inguenal Ant-2 Interfile name: ME07 ME01_1
Image duration: 179.39 sec Start time: 15:26:12

TIFF name: excised nodes1-4 Interfile name: ME07_3
Image duration: 300 sec Start time: 16:22:23



TIFF name: Postexc Ant Interfile name: ME07
Image duration: 179.40 sec Start time: 16:17:13

ME08

5x5 Patient: Me08

Date of Study: 06/09/03

Patient Initials: SM

Patient History:

Sex: F

Age: 31

Location of Tumor/Lesions: Melanoma, left lower leg. nodular growth pattern

Breslow Thickness: 1.95mm

Clark Level: at least IV

Surgeon: Murray

Images/Data of study:

Preop Images: GE 400 Emory nuclear med staff

OR Images: 5 x 5 gamma camera

Tissue Resected:

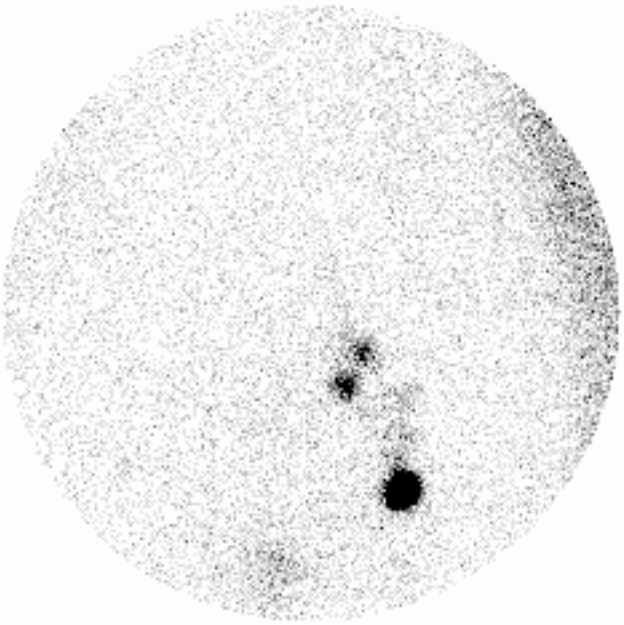
Neoprobe

Sample ID	Indicator	Post-ex count	OR Img Activity	Location
1	Hot/Blue	24794	5387	Left inguenal femerol

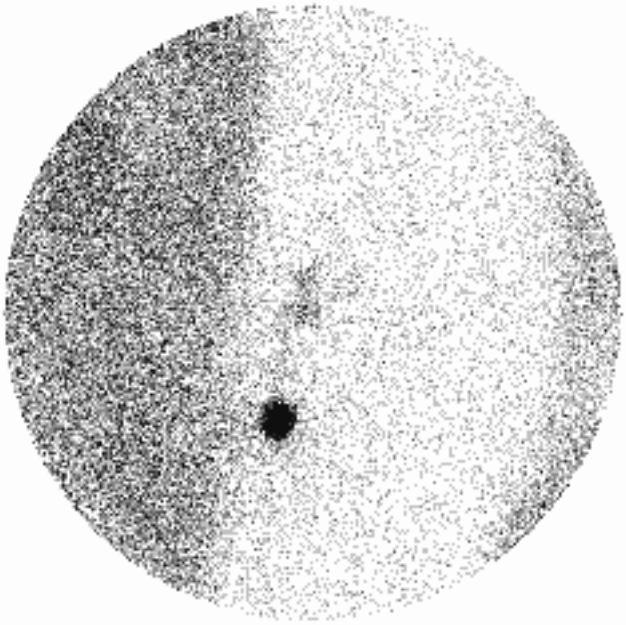
Pathology: Hot SN #1 (0/1) non-blue, measures 4.4 x 3.0 x 1.0cm.

Comments/Discussion: The melanoma is located on the lower left leg and measures 2.0mm (by outside report). The patient was injected at 8:50 with 0.194mCi of Tc99m sulfur colloid. Surgery began at 11:35 hours. The node was not positive. There was nothing significant to note about this patient.

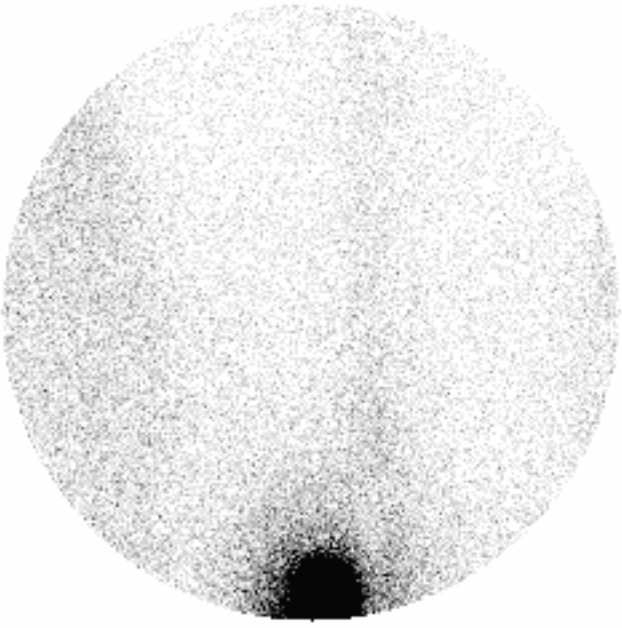
Preop Images



ANTPEL 15MIN

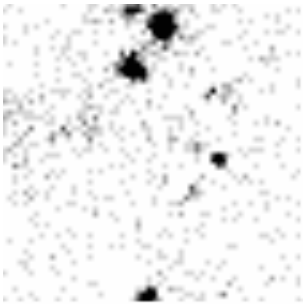


LTLATPEL 20MIN

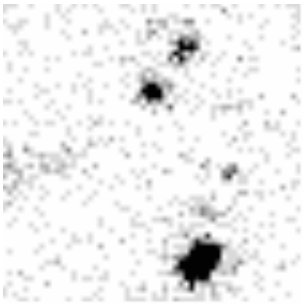


POSTLTKNEE

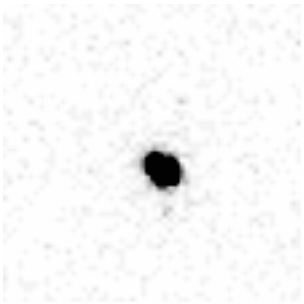
OR Images



TIFF name: preincision Interfile name: ME08_1
Image duration: 180 sec Start time: 10:29:54



TIFF name: postexcision Interfile name: ME08_2
Image duration: 180 sec Start time: 11:46:13



TIFF name: excised node Interfile name: ME08_3
Image duration: 300 sec Start time: 11:50:53

ME09

5x5 Patient: Me09

Date of Study: 06/09/03

Patient Initials: JL

Patient History: 2years ago Dr. noticed and said watch, 2 mths ago started changing colors.

Sex: F

Age: 39

Location of Tumor/Lesions: melanoma right lower leg. Superficial spreading pattern.

Breslow Thickness: 0.9mm

Clark Level: III-IV

Surgeon: Murray

Images/Data of study:

Preop Images: GE 400 Emory nuclear med staff

OR Images: 5 x 5 gamma camera

Tissue Resected:

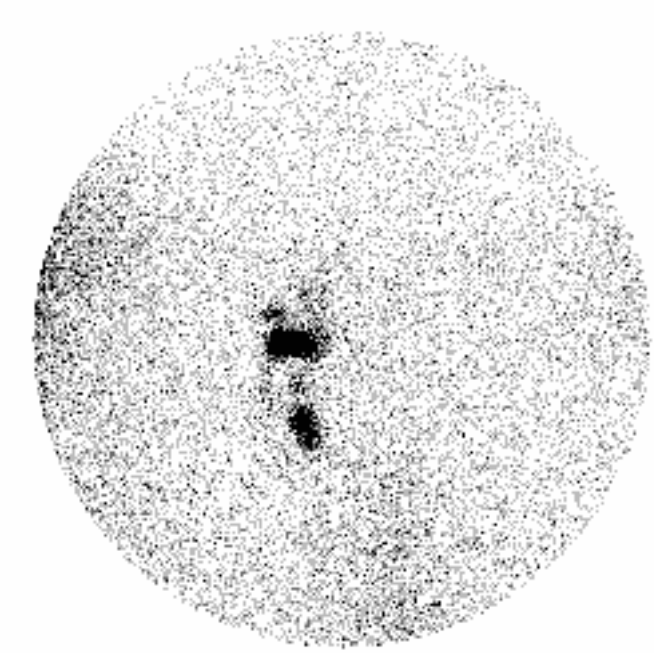
Neoprobe

Sample ID	Indicator	Post-ex count	OR Img Activity	Location
1	Hot/Blue	6711	1607	Rt Inguenal Femoral
2	Hot/Blue	13917	1706	Mid-Inguenal, lat-rt
3	Hot/Blue	5940	858	Mid-inguenal medial
4	Hot	938	255	Mid Supra Inguenal
5	Hot	694	81	Mid Supra Inguenal

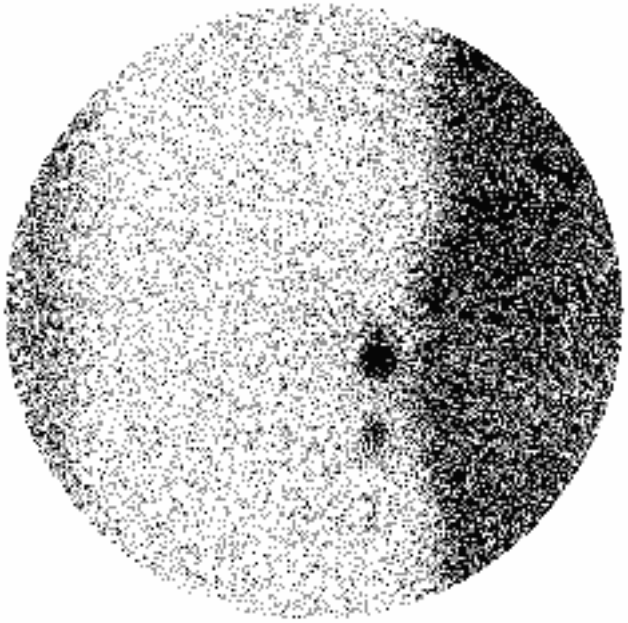
Pathology: Hot SN #1 (0/2) blue, sentinel node measures 2.6cm in greatest dimension; Hot SN #2 (0/1), blue, sentinel node measures 2.6cm in greatest dimension; Hot SN #3 (0/1), non-blue, sentinel node measures 1.5cm in greatest dimension; Hot SN #4 (0/1), non-blue, SN measures 1.3cm in greatest dimension; Hot SN #5 (0/1), non-blue, SN measures 1.4cm in greatest dimension.

Comments/Discussion: The melanoma is located on the right lateral calf and measures 0.95mm (by outside report). The patient was injected at 10:30 with 0.216mCi of Tc99m sulfur colloid. Surgery began at 14:05 hours. There were 0 positive nodes of 6 total. There was nothing significant to note about this case.

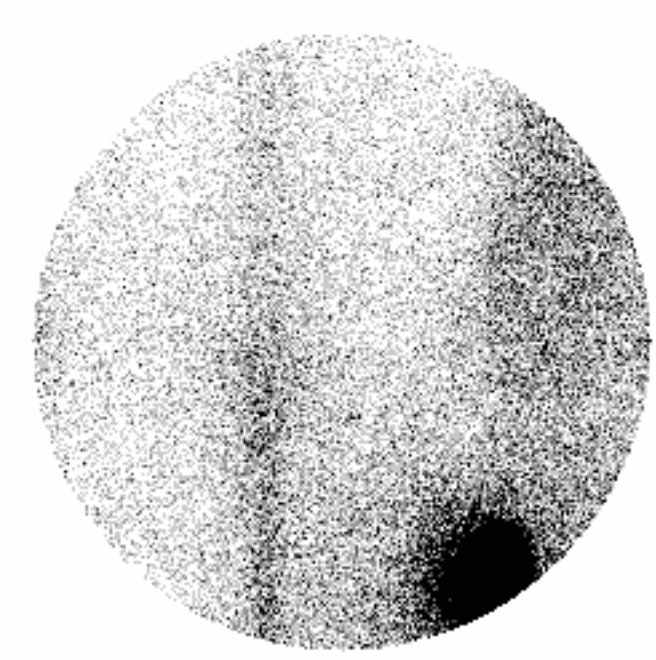
Preop Images



ANTPEL 15MIN



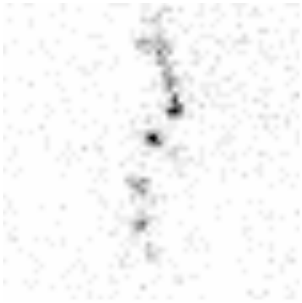
RTLAT 20MIN



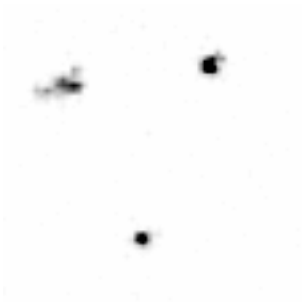
POSTKNEE 25MIN

OR Images

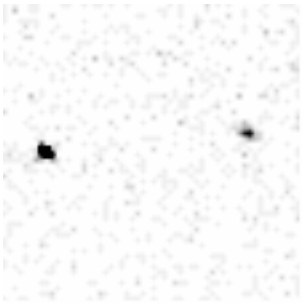
TIFF name: preincision Interfile name: ME09_1
Image duration: 180 sec Start time: 13:09:56



TIFF name: postexcision Interfile name: ME09_2
Image duration: 180 sec Start time: 14:52:16



TIFF name: excised nodes1_3 Interfile name: ME09_3
Image duration: 300sec Start time: 14:58:42



TIFF name: excised nodes4_5 Interfile name: ME09_4
Image duration: 300 sec Start time: 15:04:30

ME10

5x5 Patient: Me10

Date of Study: 06/12/03

Patient Initials: VS

Patient History: Patient first noticed in 03/2003. Mother had skin cancer on face.

Sex: F

Age: 41

Location of Tumor/Lesions: Melanoma lower left thigh, superficial spreading pattern. Ulceration absent. Initially excised and measured at .99mm

Breslow Thickness: 1.5mm

Clark Level: IV

Surgeon: Murray

Images/Data of study:

Preop Images: GE 400 Emory nuclear med staff

OR Images: 5 x 5 gamma camera

Tissue Resected:

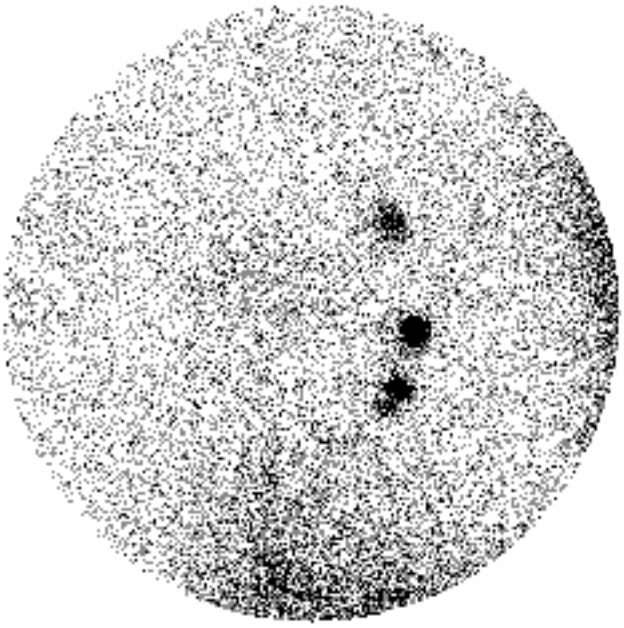
Neoprobe

Preop focus	Sample ID	Indicator	Post-ex count	OR Img Activity	Location
1	1	Hot/Blue	1132	466	Lt fossa, anterior
2	2	Hot/Blue	452	1139	Fossa poster Lt side

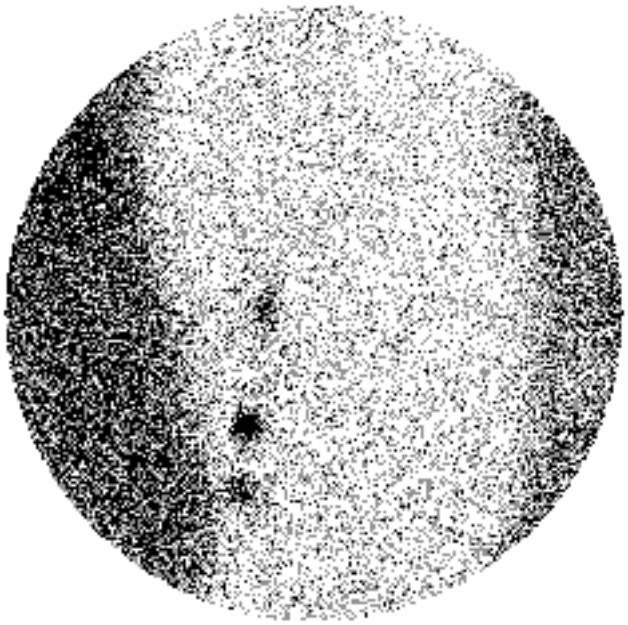
Pathology: Hot SN #1 (0/1) blue, node measures 2.5 x 1.5 x 0.7cm; Hot SN #2 (0/1) blue, node measures 0.7 x 0.5 x0.5.

Comments/Discussion: The melanoma is located on the left thigh (left mid posterior thigh) and measures 0.99mm (by outside report). The patient was injected at 8:55 with 0.198mCi of Tc99m sulfur colloid. Surgery began at 12:22 hours. There were 0 nodes positive out of a total of 2 nodes. There was nothing significant noted about this case.

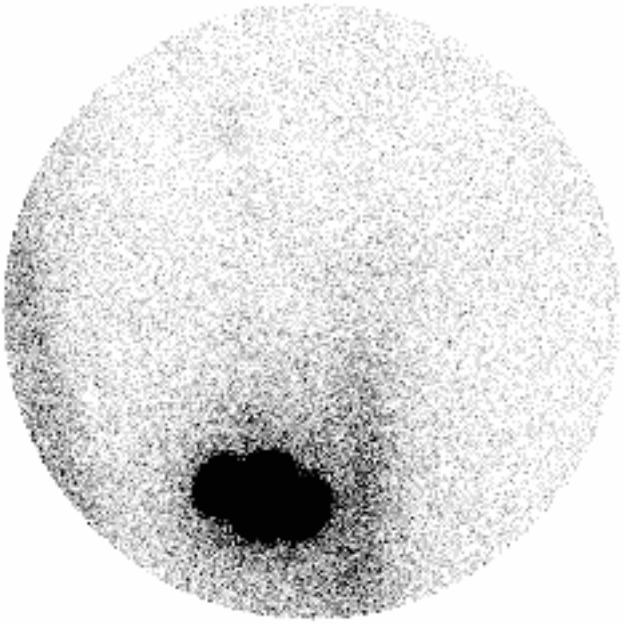
Preop Images



ANT 15MIN

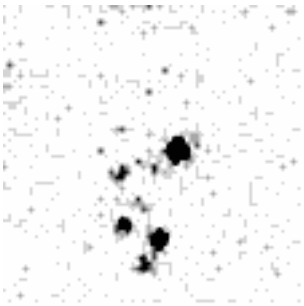


LTLAT 25MIN

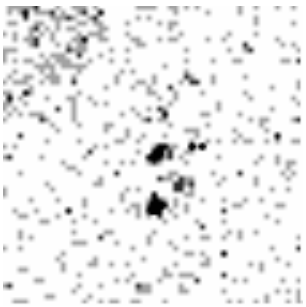


POSTKNEEINJ

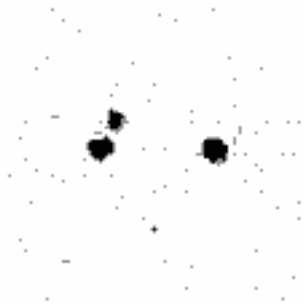
OR Images



TIFF name: preincision Interfile name: ME10_1
Image duration: 180 sec Start time: 12:10:57



TIFF name: postexcision Interfile name: ME10_2
Image duration: 180 sec Start time: 14:07:16



TIFF name: excised nodes Interfile name: ME10_3
Image duration: 300sec Start time: 14:13:43

ME11

5x5 Patient: ME11

Date of Study: 07/10/03

Patient Initials: DB

Patient History: first occurrence of skin cancer

Sex: M

Age: 46

Location of Tumor/Lesions: left lower arm just below elbow

Breslow Thickness: 1.45mm

Clark Level: at least level IV

Surgeon: Murray

Images/Data of study:

Preop Images: GE 500 Emory nuclear medicine staff

OR Images: 5 x 5 gamma camera

Tissue Resected:

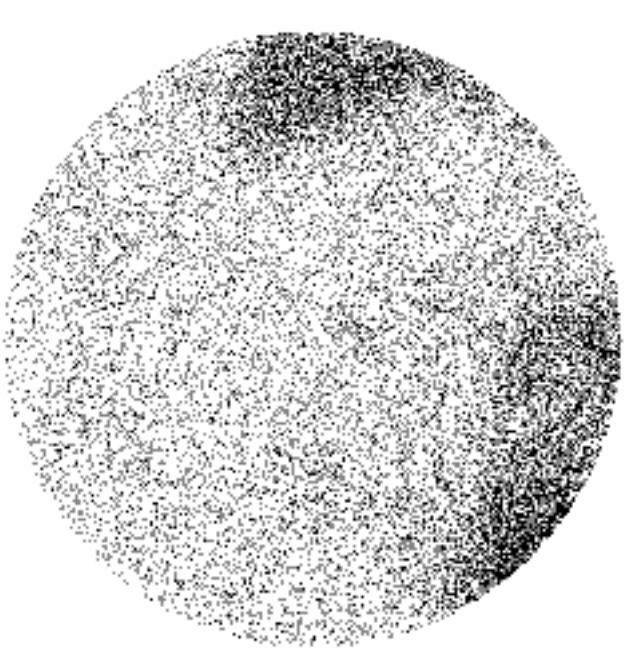
Neoprobe

Sample ID	Indicator	Post-ex count	OR Img Activity	Location
1	Hot/Blue	1143	180	Subscapular fossa ant
2	Hot/Blue	462	48	Subscapular fossa post

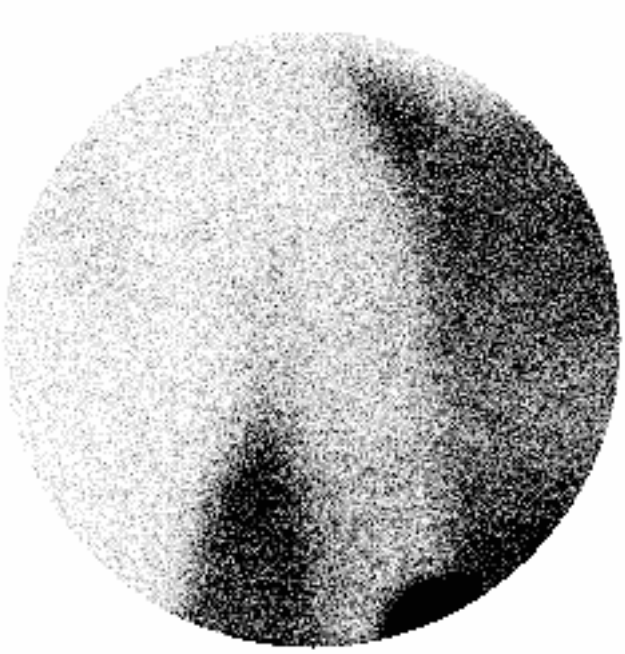
Pathology: Hot SN #1 (0/1) blue, node & tissue measures 3.0 x 1.7 x 0.9cm; Hot SN #2 (0/1) blue, node measures 2.1 x 2.5 x1.0.

Comments/Discussion: The melanoma is located on the left arm behind elbow (posterior lateral left forearm) and measures 1.35mm (by outside report). The patient was injected at 8:50 with 0.198mCi of Tc99m sulfur colloid. Surgery began at 11:40 hours. There were 0 nodes positive out of a total of 2 nodes. There was nothing significant noted about this case.

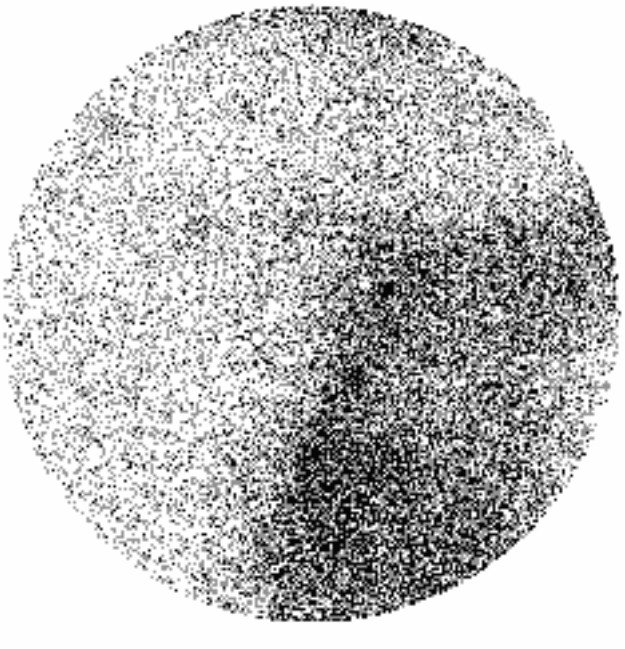
Preop Images



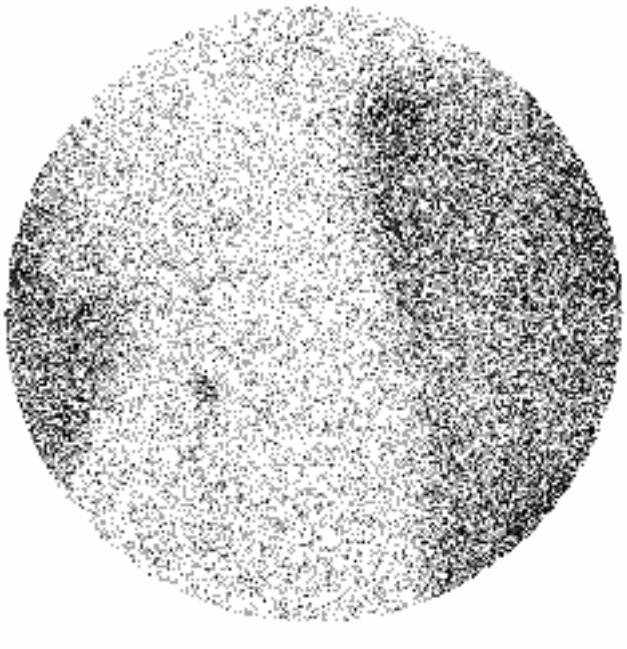
LAO 15MIN



LTARM 20MIN

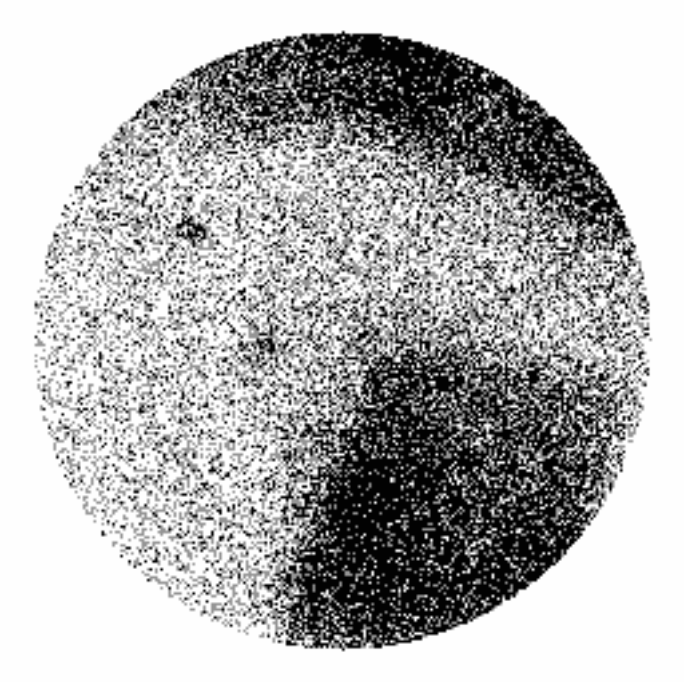


LAO 30MIN



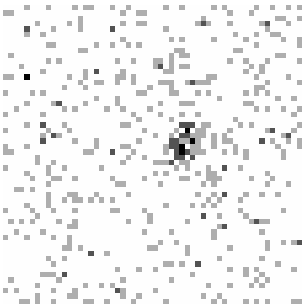
LTAX 35MIN

ME11

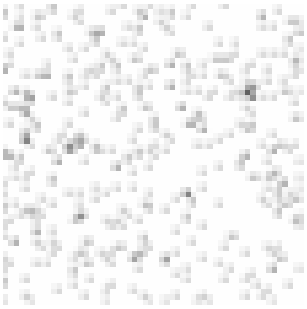


ANT 45MIN

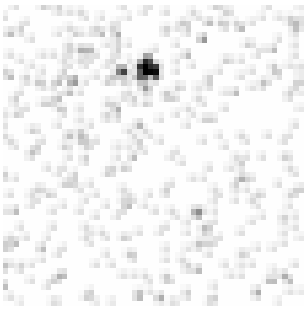
OR Images



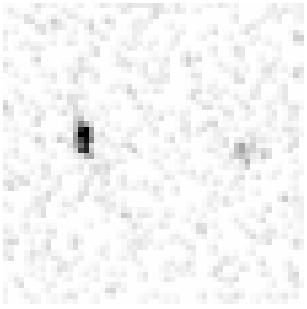
TIFF name: preincision Interfile name: ME11_1
Image duration: 180 sec Start time: 12:05:22



TIFF name: postexcision Interfile name: ME11_2
Image duration: 180 sec Start time: 12:58:12



TIFF name: clavicular Interfile name: ME11_3
Image duration: 180 sec Start time: 13:03:15



TIFF name: excised node 1_2 Interfile name: ME11_4
Image duration: 300sec Start time: 13:09:38

5x5 Patient: ME12

Date of Study: 07/10/03

Patient Initials: PP

Patient History: Brother has melanoma, father basal cell carcinoma

Sex: M

Age: 56

Location of Tumor/Lesions: Melanoma on right forearm

Breslow Thickness: 2.25mm

Clark Level: level IV

Surgeon: Murray

Images/Data of study:

Preop Images: GE 500 Emory nuclear medicine staff

OR Images: 5 x 5 gamma camera

Tissue Resected:

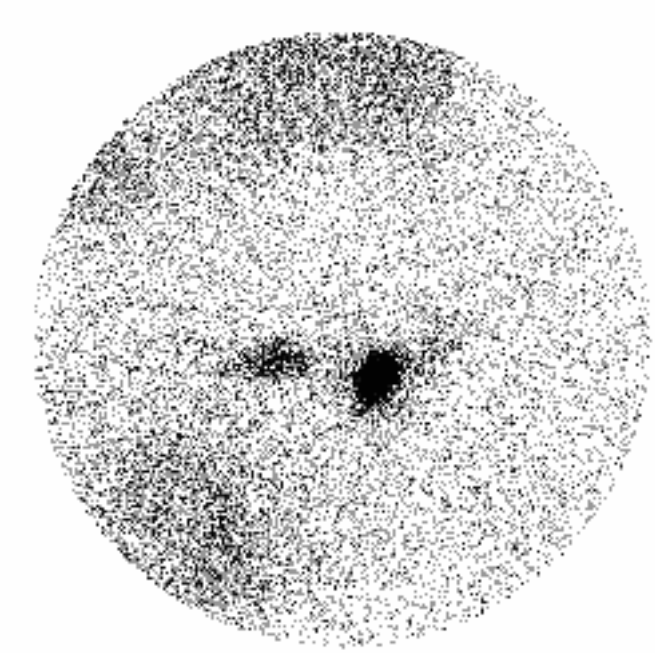
Neoprobe

Sample ID	Indicator	Post-ex count	OR Img Activity	Location
1	Hot/blue	4630	2180	Upper level 1 rtaxilla
2	Hot	482	133	Upper level 1 rtaxilla (only deeper)

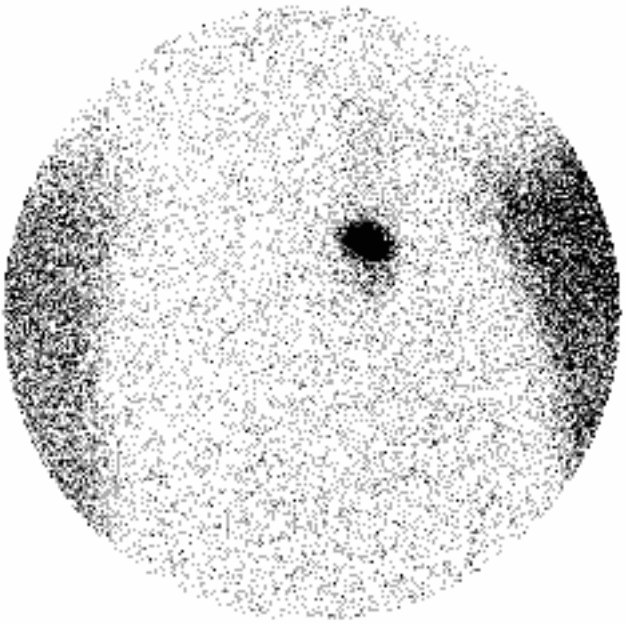
Pathology: Hot SN #1 (0/1) blue, node measures 4.0 x 2.0 x 1.0cm; Hot SN #2 (0/1) blue, node measures 2.0 x 1.0 x 0.8cm.

Comments/Discussion: The melanoma is located on the right forearm (proximal dorsal right forearm) and measures 2.5mm. The patient was injected at 11:00 with 0.186mCi of Tc99m sulfur colloid. Surgery began at 16:30 hours. There were 0 nodes positive out of a total of 2 nodes. There was nothing significant noted about this case.

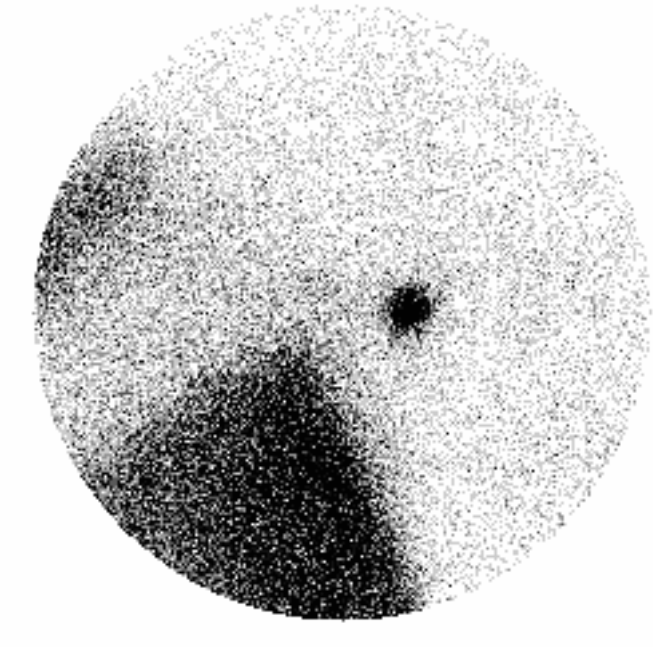
Preop Images



RAO 15MIN

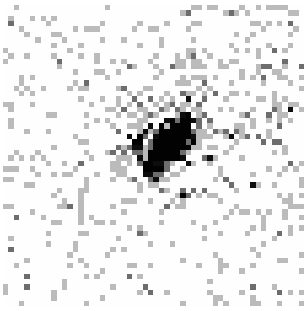


RTLAT RTAX

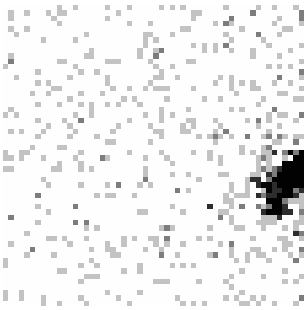


ANT 25MIN

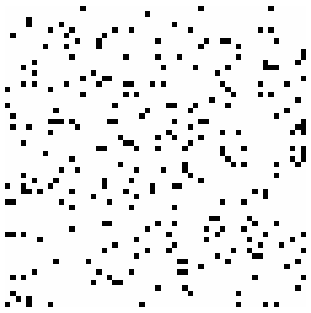
OR Images



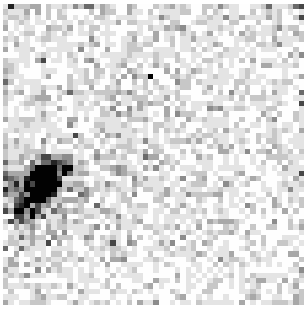
TIFF name: Preinc focus-1 Interfile name: ME12_1
Image duration: 180 sec Start time: 16:11:28



TIFF name: Preinc focus-2a Interfile name: ME12_2
Image duration: 180 sec Start time: 16:16:31

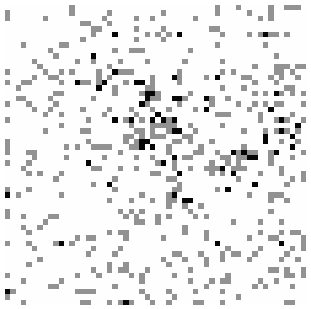


TIFF name: Preinc focus-2b Interfile name: ME12_3
Image duration: 120 sec Start time: 16:20:19

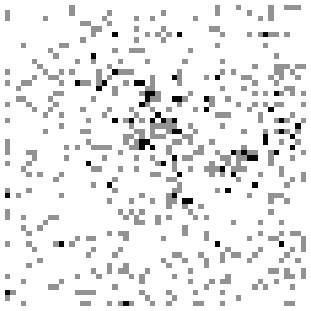


TIFF name: Preinc focus-1a Interfile name: ME12_4
Image duration: 120 sec Start time: 16:24:19

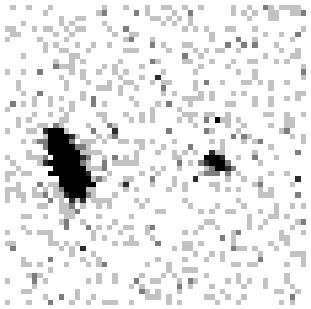
ME12



TIFF name: Preinc sterile Interfile name: ME12_5
Image duration: 120 sec Start time: 16:49:31



TIFF name: Postexcision sterile Interfile name: ME12_8
Image duration: 180 sec Start time: 17:34:32



TIFF name: masses Interfile name: ME12_9
Image duration: 300 sec Start time: 17:44:00

5x5 Patient: ME13

Date of Study: 07/17/03

Patient Initials: AM

Patient History: No history of skin cancer

Sex: F

Age: 33

Location of Tumor/Lesions: right buttock

Breslow Thickness: 1.75

Clark Level: IV

Surgeon: Murray

Images/Data of study:

Preop Images: GE 500 Emory nuclear medicine staff

OR Images: 5 x 5 gamma camera

Tissue Resected:

Neoprobe

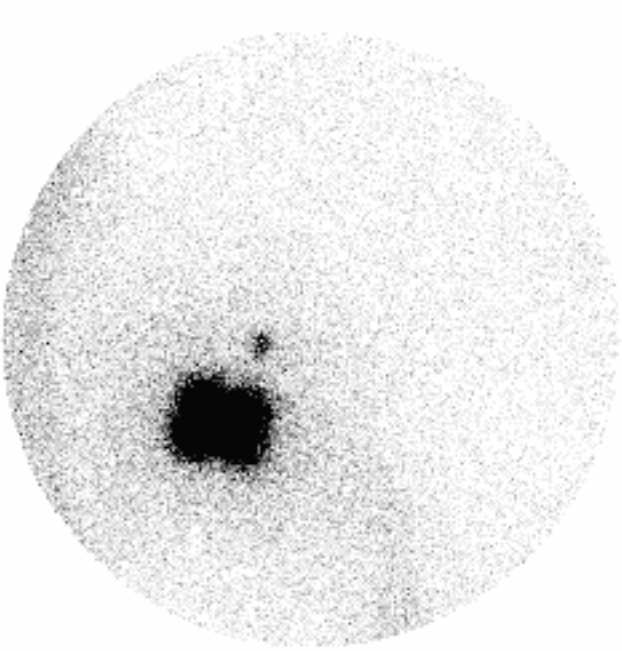
Sample ID	Indicator	Post-ex count	OR Img Activity	Location
1	Hot/blue	3104	433	Rt lateral inguenal

Pathology: SN #1 (1/1), node measures 1.1 x 0.6 x 0.3 cm.

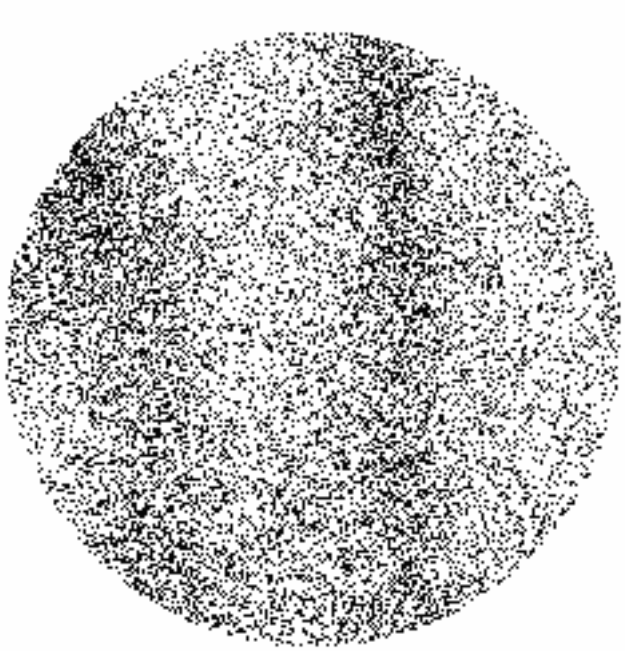
Comments/ Discussion: The melanoma is located on the right buttock was measured to be 1.75mm by outside report . The patient was injected with 0.212 mCi of Tc99m sulfur colloid at 8:30. Surgery began at 13:00 hours. . The sentinel node is **positive** by IHC S-100 and negative by IHC HMB45. A re-examination of right inguinal tissue was completed a month later. Two additional samples were sent for pathology. There were 8 nodes in the two samples and 0 were positive for metastatic melanoma.

ME13

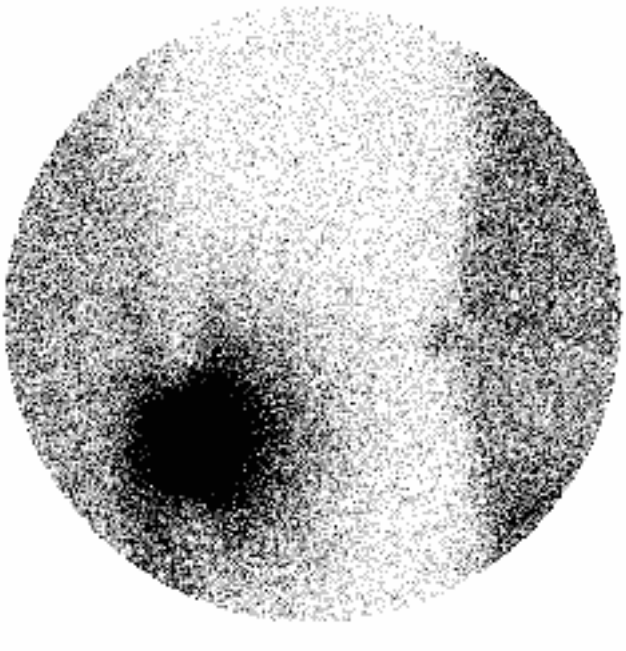
Preop Images



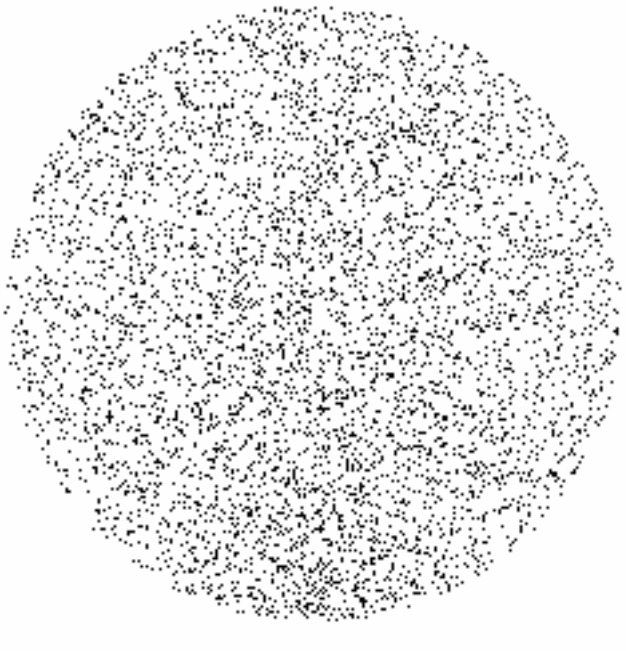
ANTPEL 15MIN



ANTKNEES 20MIN



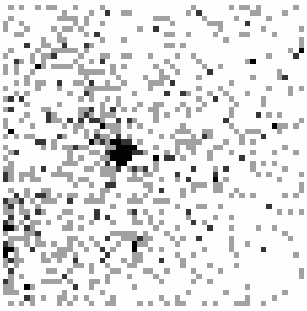
RTLATPEL 25MIN



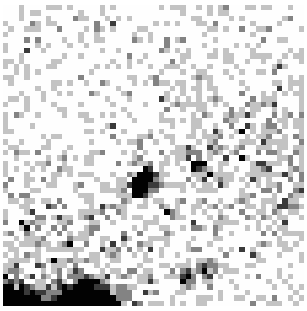
RTLATAXILLA 30MIN

ME13

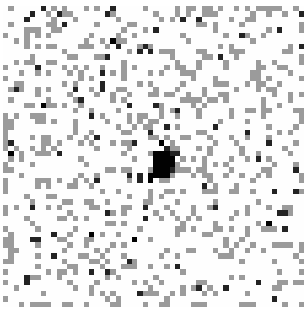
OR Images



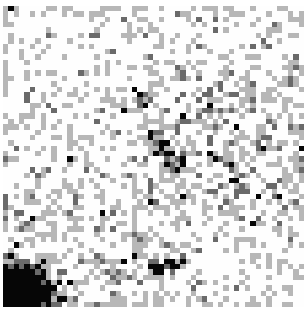
TIFF name: preincision nonsterile Interfile name: ME13_1
Image duration: 120 sec Start time: 11:24:35



TIFF name: preincision sterile Interfile name: ME13_2b
Image duration: 300 sec Start time: 12:50:59



TIFF name: excised node Interfile name: ME13_3
Image duration: 300 sec Start time: 13:22:13



TIFF name: postexcision Interfile name: ME13_3
Image duration: 300 sec Start time: 13:36:33

5x5 Patient: ME14

Date of Study: 07/24/03

Patient Initials: LS

Patient History: Previously biopsied

Sex: M

Age: 72

Location of Tumor/Lesions: Right Lower leg

Breslow Thickness: 2.1mm

Clark Level: IV

Surgeon: Murray

Images/Data of study:

Preop Images: GE 500 Emory nuclear medicine staff

OR Images: 5 x 5 gamma camera

Tissue Resected:

Neoprobe

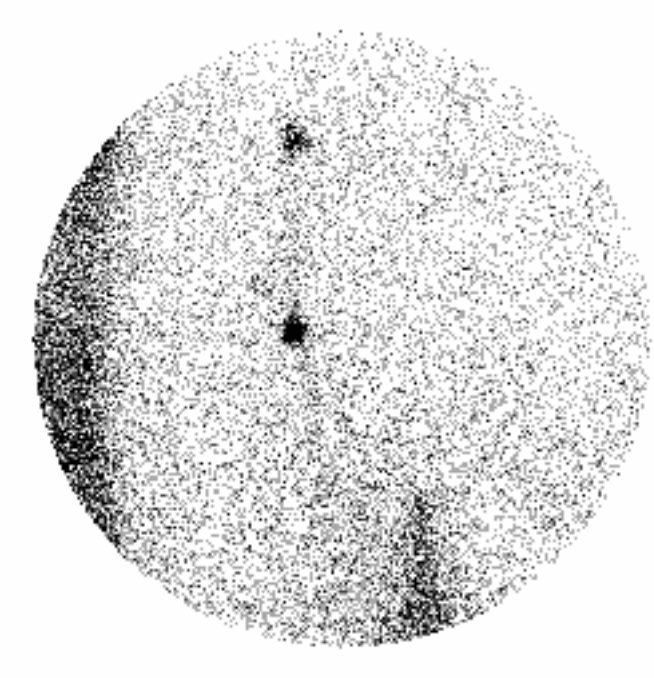
Sample ID	Indicator	Post-ex count	OR Img Activity	Location
1	Hot/Blue	1773	337	Rt inguenal femoral

Pathology: Hot SN #1 (1/1) blue, node & fibrofatty tissue measures 3.0 x 2.5 x 1.5 cm.

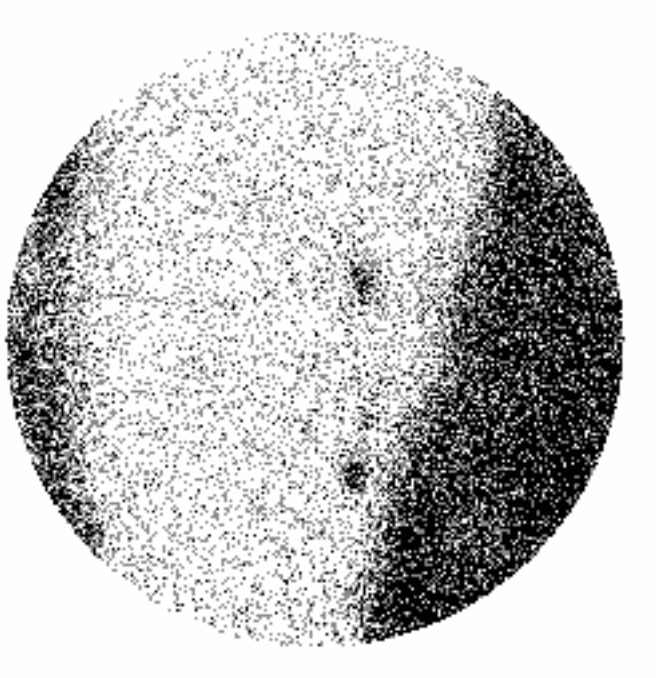
Comments/ Discussion: The melanoma is located on the right lower inner leg (proximal posteromedial right leg) was measured to be 2.1mm by outside report and 2.0mm by Emory findings. The patient was injected with 0.203 mCi of Tc99m sulfur colloid at 9:00. Surgery began at 12:00 . The sentinel node is **positive** for clusters and single cells of metastatic melanoma by both IHC S-100 and IHC HMB45 but negative by H&E stain. Because there was presence of metastatic melanoma in the two IHC the node was regarded as positive as opposed to negative because of the H&E stain.

ME14

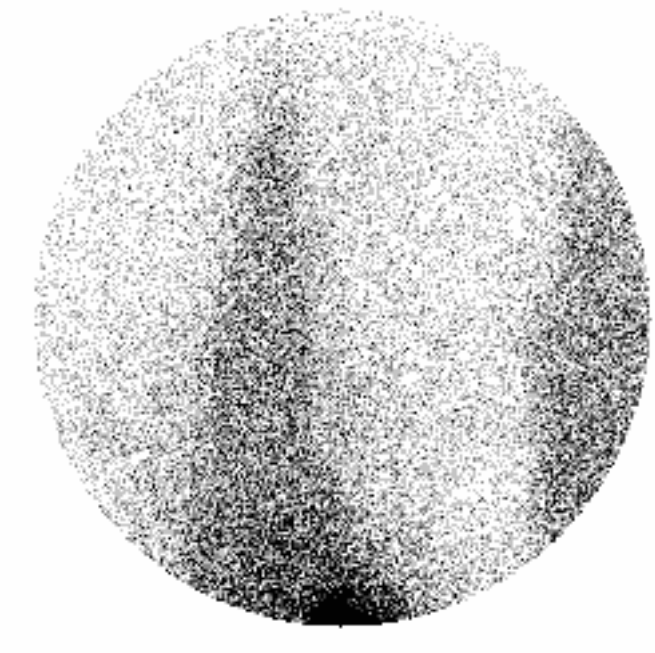
Preop Images



ANTPEL 15MIN

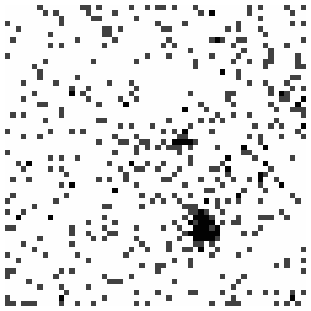


RTLATPEL 20MIN

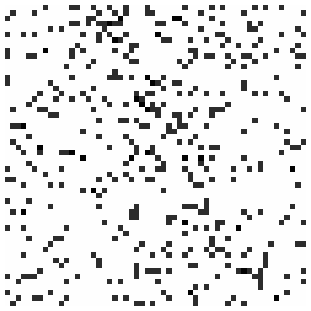


POSTRTKNEE

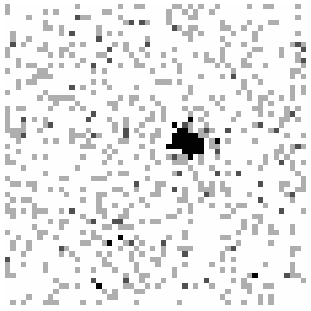
OR Images



TIFF name: preinc inguenal node Interfile name: ME14_1
Image duration: 180 sec Start time: 11:13:38



TIFF name: post excision bed Interfile name: ME14_4
Image duration: 180 sec Start time: 12:45:12



TIFF name: excised mass Interfile name: ME14_5
Image duration: 300 sec Start time: 12:51:24

ME15

5x5 Patient: Me15

Date of Study: 07/24/03

Patient Initials:

Patient History: Basal cell carcinoma removed last year from back in same area.

Sex: F

Age:

Location of Tumor/Lesions: Upper left on back near shoulder blade

Breslow Thickness:

Clark Level:

Surgeon: Murray

Images/Data of study:

Preop Images: GE 500 Emory nuclear medicine staff

OR Images: 5 x 5 gamma camera

Tissue Resected:

Neoprobe

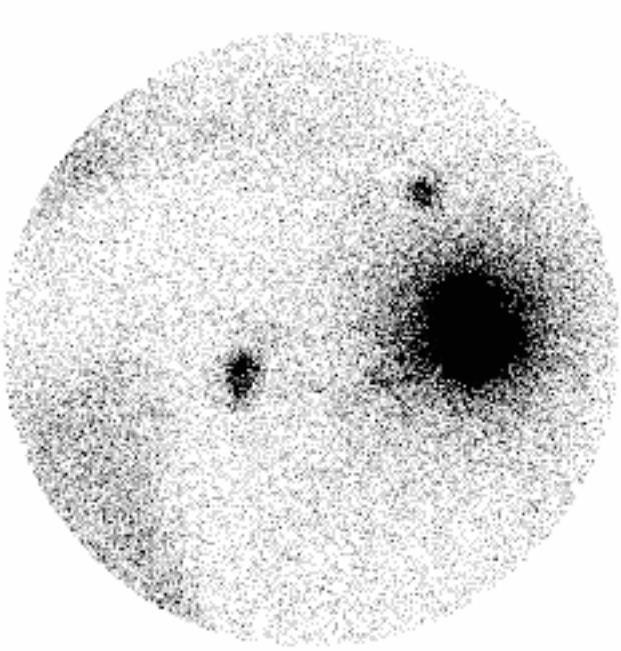
Sample ID	Indicator	Post-ex count	OR Img Activity	Location
1	Hot/Blue	1368	504	Lt nape of neck
2	Hot/Blue	1615	375	Subscapular fossa lt axilla
3	Hot	7125	1019	Deep subscapular fossa

Pathology: Hot SN #1 (0/1) blue, node measures 0.6 x 0.6 x 0.8 cm; Hot SN #2 (0/2) blue, largest node measures 3.1 x 1.3 x 0.4 cm; Hot SN #3 (0/4), non-blue, largest node measure 1.1 x 0.8 x 1.3 cm.

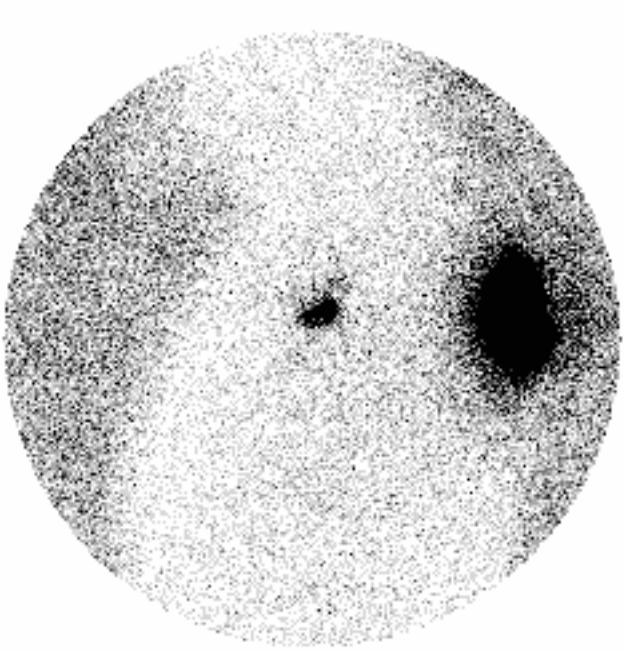
Comments/ Discussion: The melanoma is located (left mid paradorsal area) was measured to be 2.0 mm by outside report and 2.4 mm by Emory. The patient was injected with 0.196 mCi of Tc99m sulfur colloid at 10:18. Surgery began at 15:00 . Out of the three nodes submitted for pathology there were a total of 7 sentinel nodes and there were 0 positive nodes. There was nothing significant to note about this case.

ME15

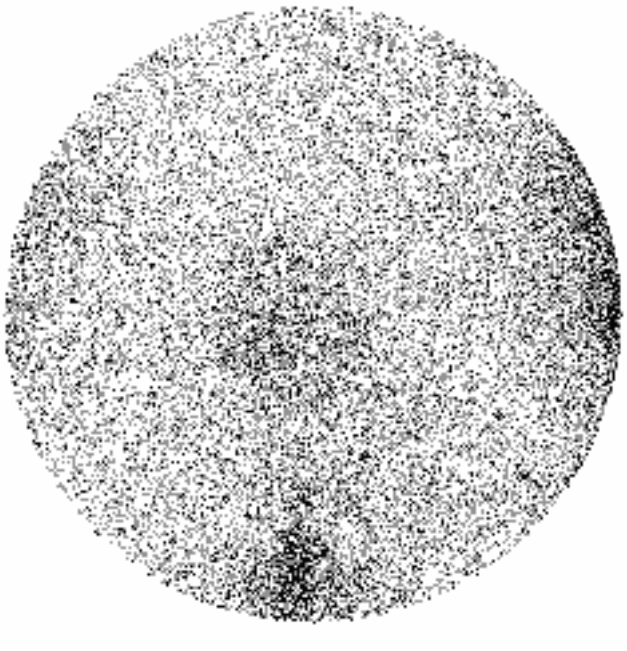
Preop Images



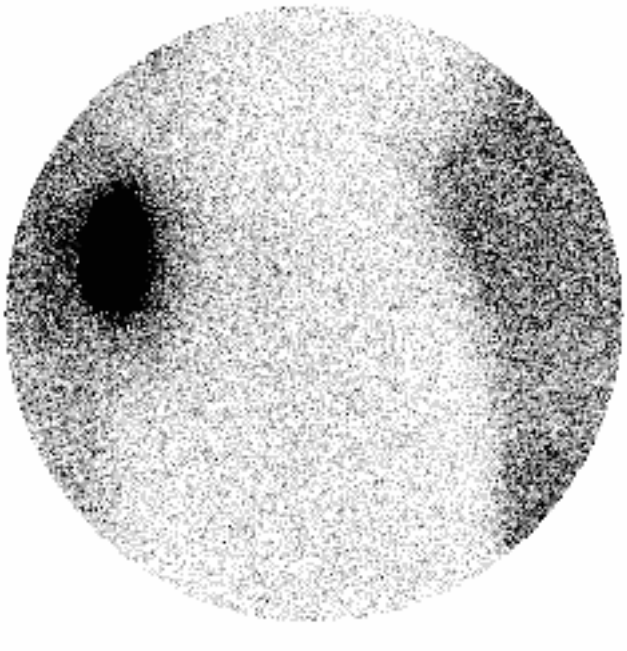
LTDORSAL 15MIN



LTLAT 20MIN

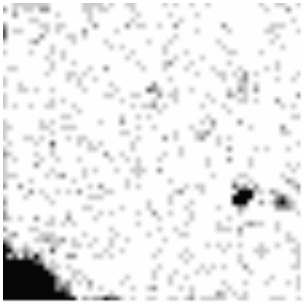


ANTPELVIS

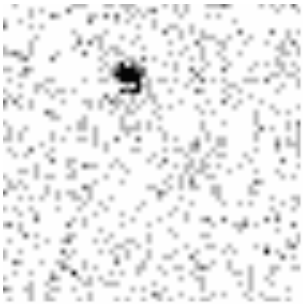


RTLAT 30MIN

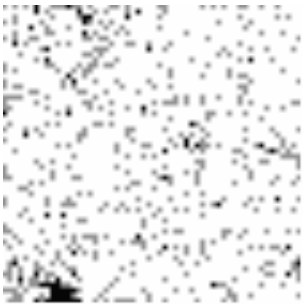
OR Images



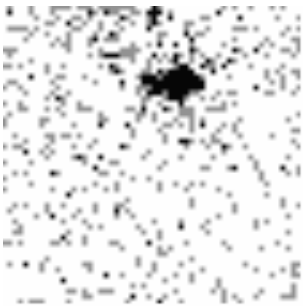
TIFF name: preincision Interfile name: ME15_2b
Image duration: 180 sec Start time: 14:40:11



TIFF name: excised node_1 Interfile name: ME15_3
Image duration: 180 sec Start time: 15:22:38

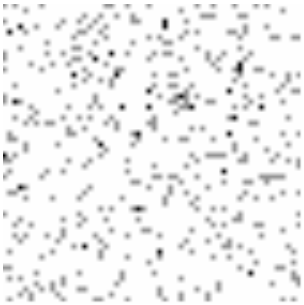


TIFF name: postexcision post Interfile name: ME15_4b
Image duration: 180 sec Start time: 15:40:21

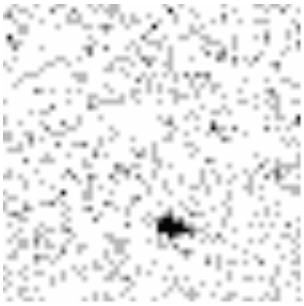


TIFF name: preincision axillary Interfile name: ME15_5
Image duration: 180 sec Start time: 16:41:16

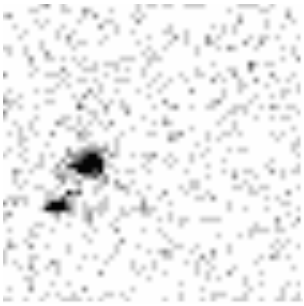
ME15



TIFF name: postexcision axillary Interfile name: ME15_6
Image duration: 180 sec Start time: 17:27:50



TIFF name: excised node_2 Interfile name: ME15_7
Image duration: 180 sec Start time: 17:35:21



TIFF name: excised node_3& nonsln Interfile name: ME15_8
Image duration: 300 sec Start time: 17:41:16

ME16

5x5 Patient: ME16

Date of Study: 07/31/03

Patient Initials: RD

Patient History: Previous melanoma on back 4 years ago, approx 1.1mm axillary nodes negative

Sex: M

Age: 69

Location of Tumor/Lesions: right anterior neck

Breslow Thickness: 1.3-1.62mm

Clark Level: IV

Surgeon: Murray

Images/Data of study:

Preop Images: GE 500 Emory nuclear medicine staff

OR Images: 5 x 5 gamma camera

Tissue Resected:

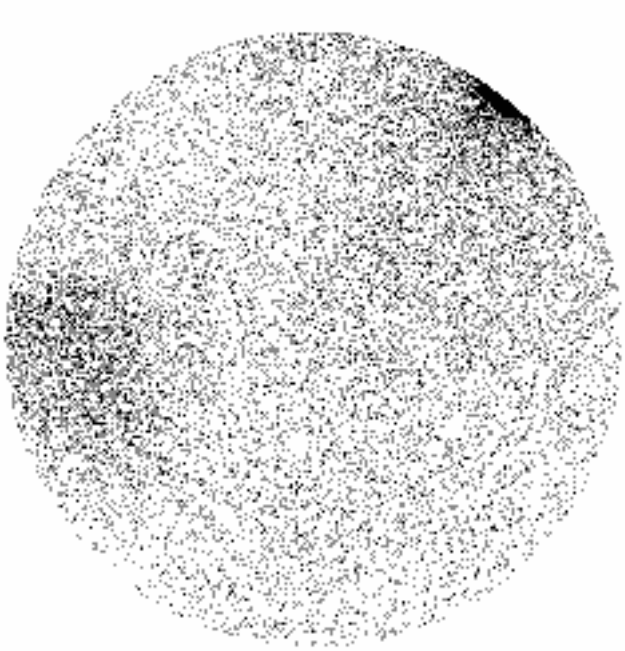
Neoprobe

Sample ID	Indicator	Post-ex count	OR Img Activity	Location
1	Hot	2118	223	Submental mid line

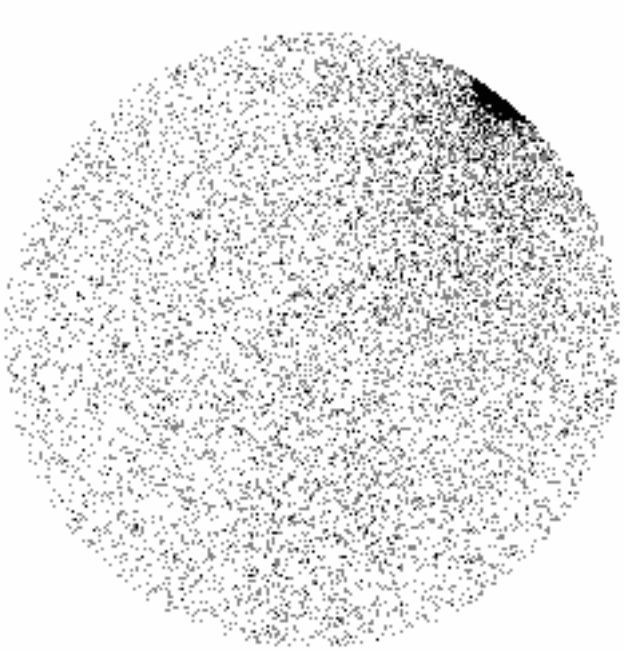
Pathology: First Case: No mention of blue dye. Hot SN #1 (0/2), nodes measure 2.0 x 1.5 x 0.4 cm and 0.5 x 0.5 x 0.3 cm; Hot SN #2 (0/1), node measures 1.0 x 1.0 x 0.5 cm. Second Case 4 years later: Hot SN #1 (0/1), non-blue, node and fibrofatty tissue measures 1.8 x 0.9 x 0.8 cm.

Comments/ Discussion: Initially the subject had intermediate thick melanoma located at the right mid-paraspinal area measured to be 1.45mm. There were no nodes found to be positive and there was no spread to the excisional margins. Four years later subject returned for wide excisional margin of thin melanoma measured 1.3 mm located mid and anterior right neck. The patient was injected with 0.192 mCi of Tc99m sulfur colloid at 8:50. Surgery began at 12:09. The 1 sentinel node submitted for pathology and was negative for metastatic melanoma.

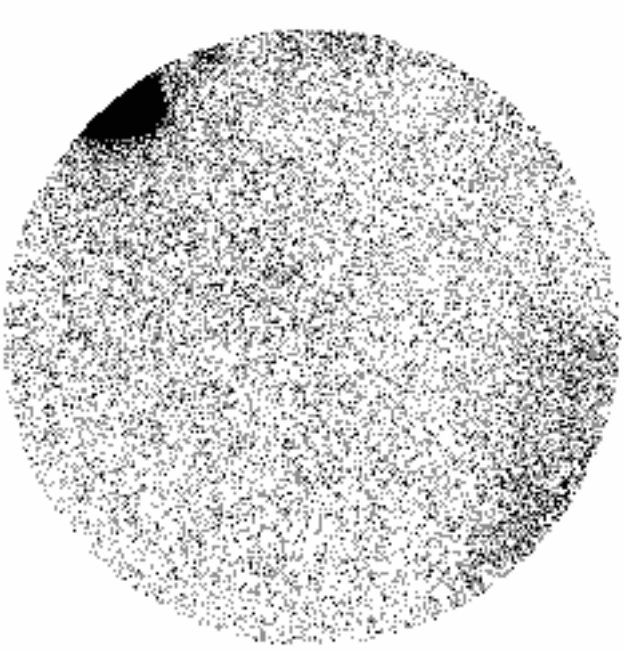
Preop Images



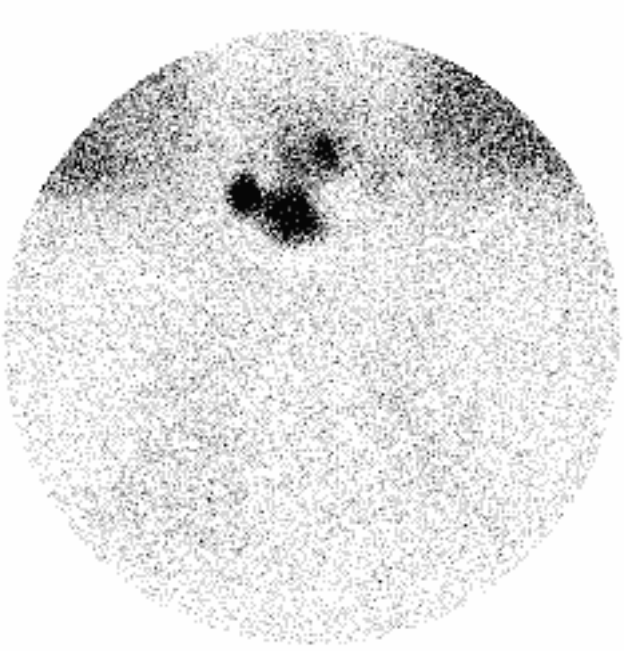
RAO 15MIN



RAONOTRANS

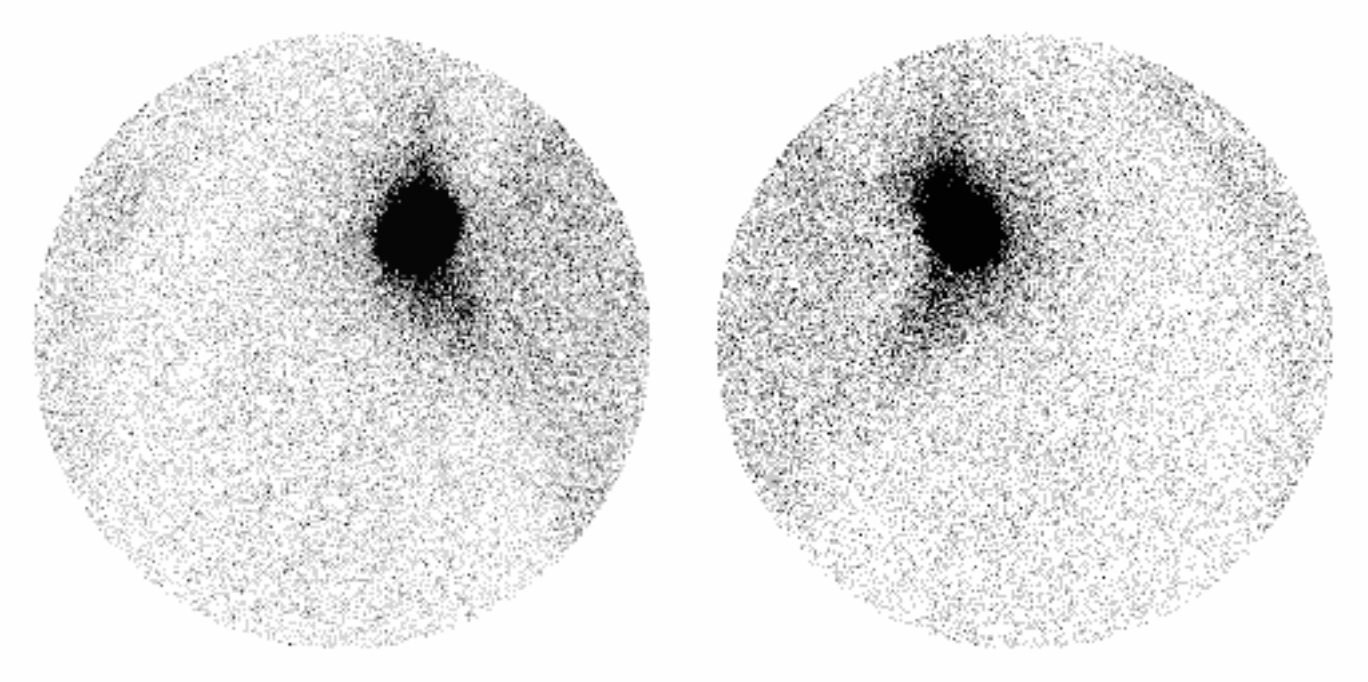


LAO 25MIN



ANT 30MIN

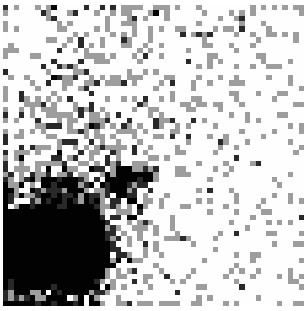
ME16



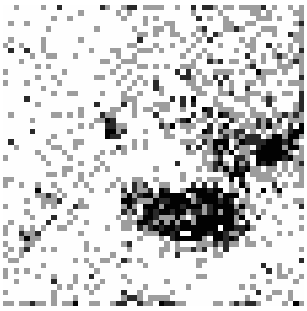
RTLATAX 50MIN **LTLATAX 55MIN**

ME16

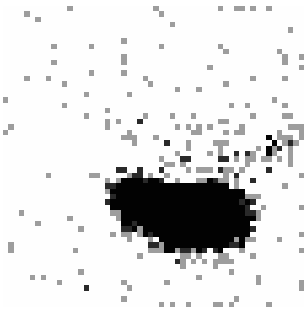
OR Images



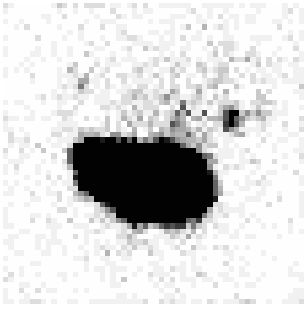
TIFF name: preincision Interfile name: ME16_1
Image duration: 180 sec Start time: 11:23:37



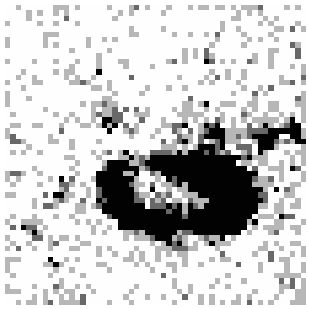
TIFF name: preincision w/ led sheild Interfile name: ME16_1b
Image duration: 180 sec Start time: 11:28:33



TIFF name: preincision w/o led shield Interfile name:ME16_1c
Image duration: 20 sec Start time: 11:31:53

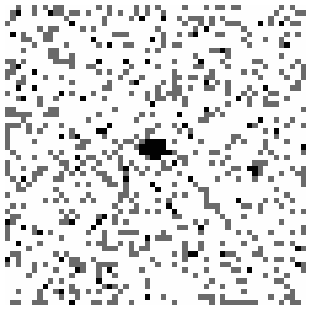


TIFF name: preincision sterile Interfile name: ME16_1
Image duration: 180 sec Start time: 11:58:42



TIFF name: postexcised tumor sterile Interfile name: ME16_3
Image duration: 180 sec Start time: 12:29:04

TIFF name: postexcised node removed Interfile name: ME16_4
Image duration: 180 sec Start time: 12:59:00



TIFF name: excised node Interfile name: ME16_5
Image duration: 300 sec Start time: 13:04:21

ME18

5x5 Patient: ME17

Date of Study: 07/31/03

Patient Initials: PR

Patient History: Lesion was noted 3-4 months ago, it was new & dark, developed cellolitus in the biopsy.

Sex: M

Age: 50

Location of Tumor/Lesions: Left foot anterior near toes.

Breslow Thickness: 2.5mm

Clark Level: IV

Surgeon: Murray

Images/Data of study:

Preop Images: GE 500 Emory nuclear medicine staff

OR Images: 5 x 5 gamma camera

Tissue Resected:

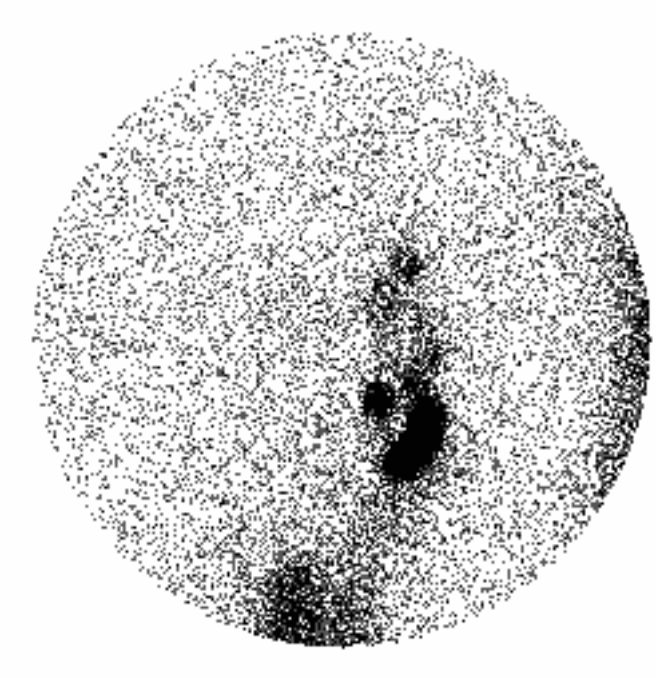
Neoprobe

Sample ID	Indicator	Post-ex count	OR Img Activity	Location
1	Hot	10,817	3484	Lt inguenal femoral

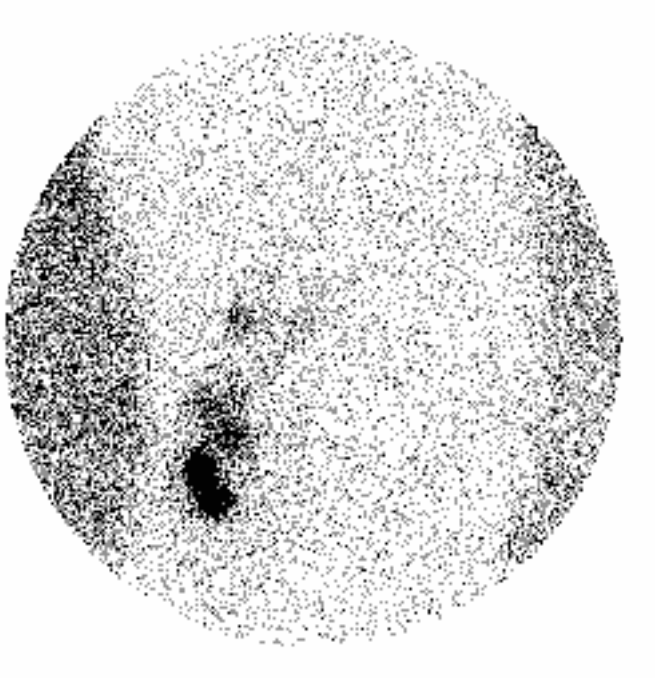
Pathology: No mention of blue dye. Hot SN #1 (1/2), nodes measure 2.1 x 1.9 x 1.0 cm and 1.7 x 1.3 x 0.6 cm.

Comments/ Discussion: The melanoma is located on the left foot (dorsum left foot) was measured to be 2.4 mm by outside report and 2.5 mm by Emory. The patient was injected with 0.171 mCi of Tc99m sulfur colloid at 10:44. Surgery began at 16:00. Out of the 1 node submitted for pathology there were a total of 2 sentinel nodes and there was 1 **positive** node. Because of the positive node the subject returned for a full ALD. There were a total of 33 nodes, only 1 node was found to be positive for metastatic melanoma.

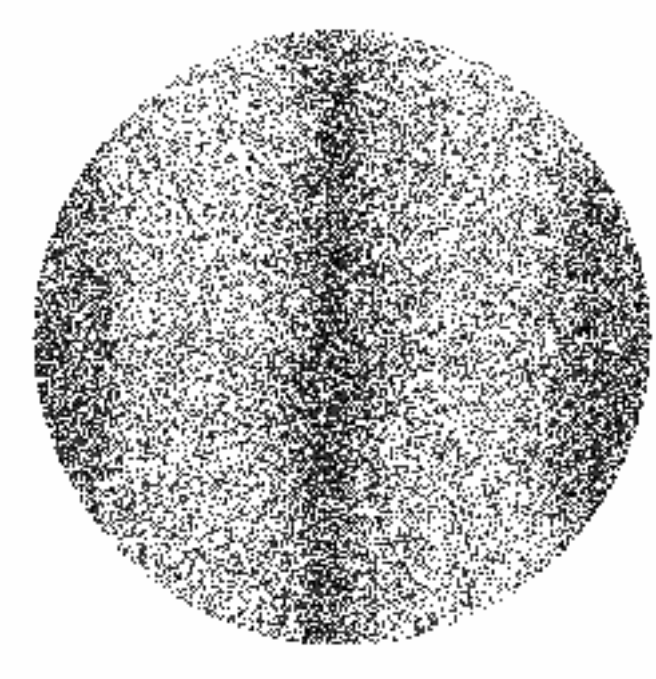
Preop Images



ANTPEL 15MIN



LTLATPEL 20MIN

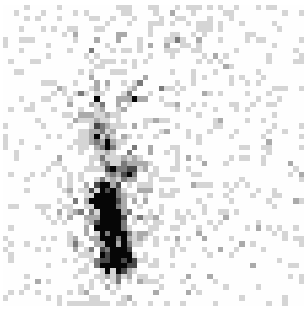


POSTLTKNEE

ME18

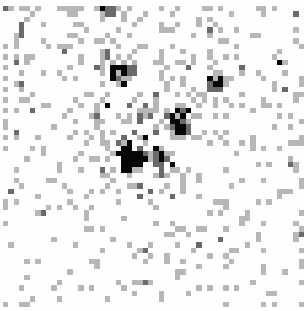
OR Images

TIFF name: preincision ant Interfile name: ME17_1a
Image duration: 180 sec Start time: 15:08:06



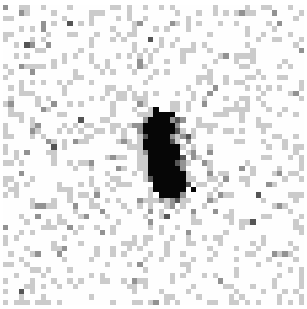
TIFF name: preincision ltlat Interfile name:ME17_1b
Image duration: 180 sec Start time: 15:13:29

TIFF name: preincison sterile Interfile name:ME17_2
Image duration: 300 sec Start time: 16:10:10



TIFF name: postexcision sterile Interfile name:ME17_3
Image duration: 180 sec Start time: 17:06:33

ME18



TIFF name: excised node Interfile name:ME17_4
Image duration: 300sec Start time: 17:12:03

ME18

5x5 Patient: ME18

Date of Study: 08/04/03

Patient Initials: PR

Patient History: Noted mole in 2002, recently noted to be increasing in size, changing color a bleeding easily

Sex: M

Age: 44

Location of Tumor/Lesions: left shoulder

Breslow Thickness: 2.35mm

Clark Level: IV

Surgeon: Murray

Images/Data of study:

Preop Images: GE 500 Emory nuclear medicine staff

OR Images: 5 x 5 gamma camera

Tissue Resected:

Neoprobe

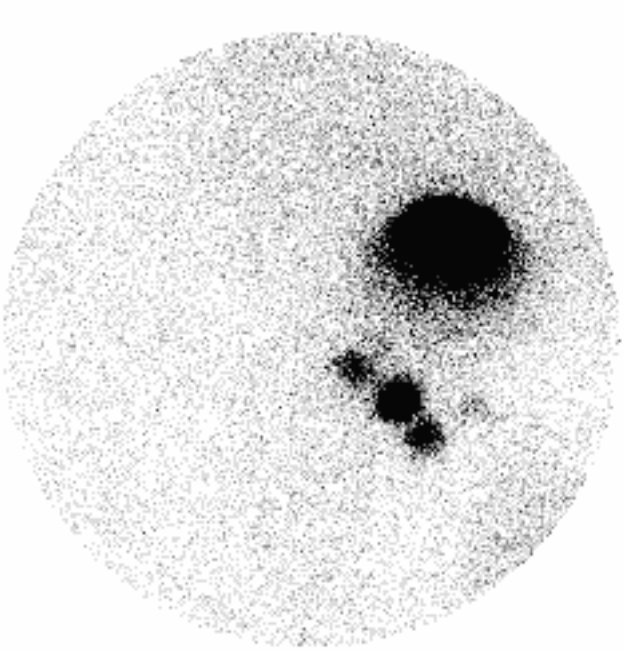
Sample ID	Indicator	Post-ex count	OR Img Activity	Location
1	Hot	16376	3191	Upper post level 1 lt axilla
2	Hot	4234	1326	Subscapular fossa
3	Hot	1194	186	Medial pectoral nerve
4	Hot	3386	544	Pectoral nerve at apex of lt axilla

Pathology: Hot SN #1 (1/1), non- blue, node measures 1.1 x 1.1 x 0.6 cm; Hot SN #2 (0/1), non-blue, node measures 1.4 x 1.0 x 0.6 cm; Hot SN #3 (0/1), non-blue, node measure 1.3 x 0.6 x 0.4 cm; Hot SN #4 (1/1), non-blue, node measures 1.1 x 1.0 x 0.4 cm.

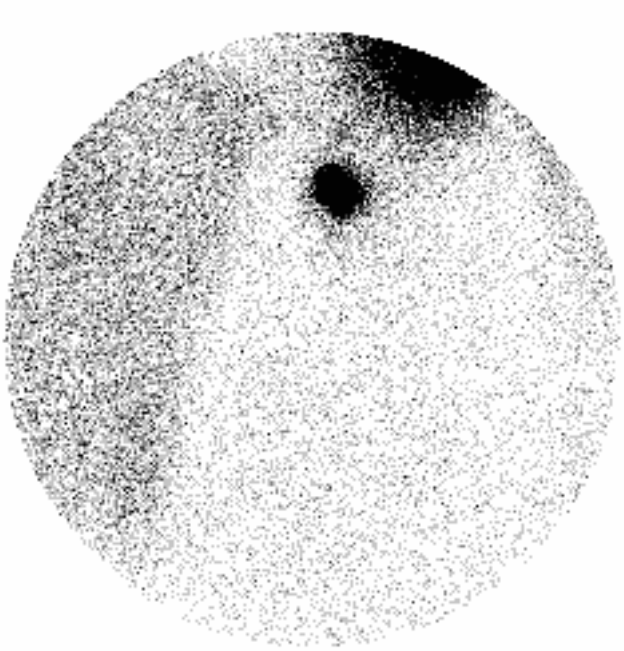
Comments/ Discussion: The melanoma is located left shoulder (posterior cap of left shoulder) and was measured to be 2.35 mm by outside report and 2.35 mm by Emory. The patient was injected with 0.231 mCi of Tc99m sulfur colloid at 8:38. Surgery began at - . Out of the 4 nodes submitted for pathology there was 1 **positive** node. As a result of the positive node the subject returned two months later for a more complete dissection of the left axilla. 7 nodes were submitted and 0 were positive for metastatic melanoma

ME18

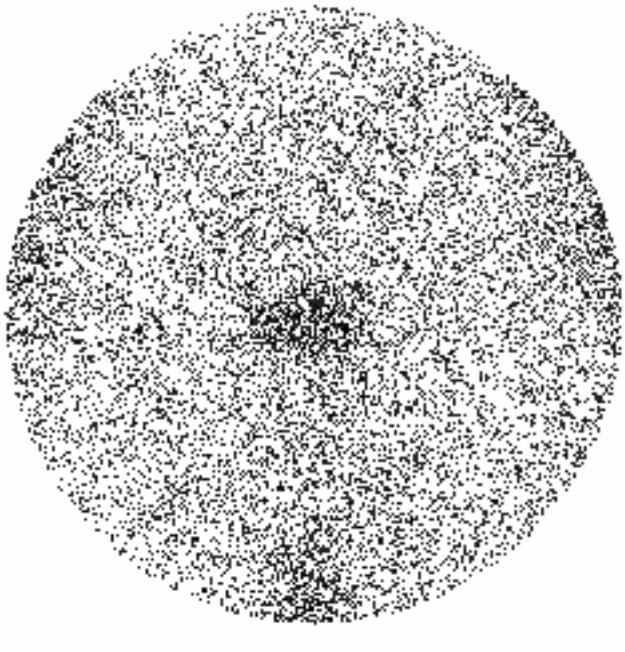
Preop Images



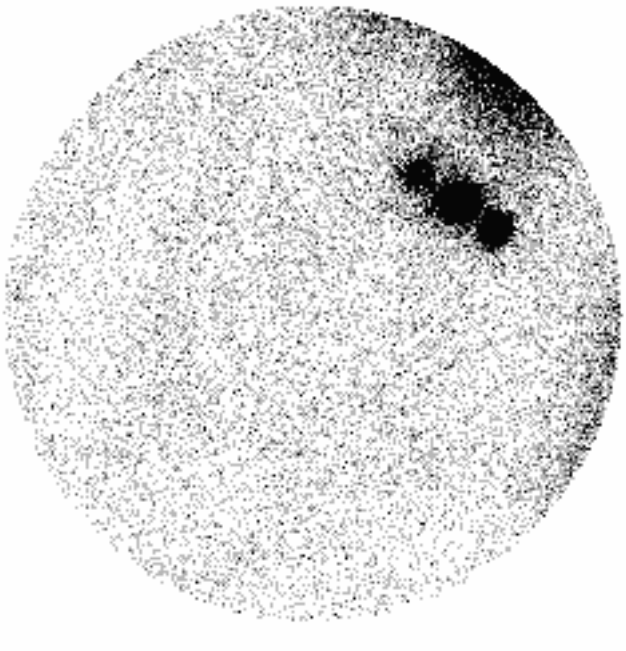
ANT 10MIN



LTLATAX 20MIN



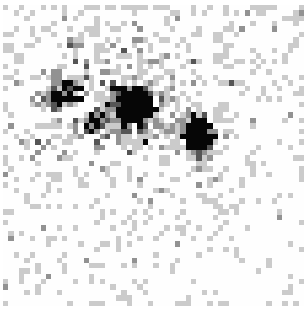
ANTPELVIS



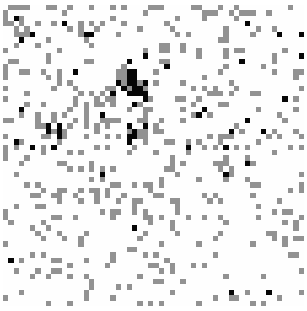
LAO45 50MIN

ME18

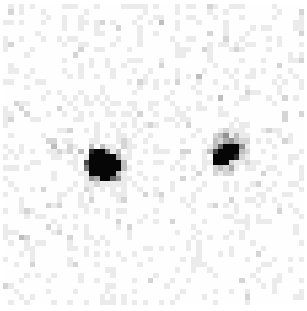
OR Images



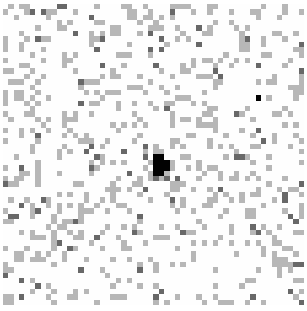
TIFF name: preincision sterile Interfile name: ME18_1
Image duration: 180 sec Start time: 10:29:54



TIFF name: postexcision Interfile name: ME18_2
Image duration: 180 sec Start time: 15:32:48

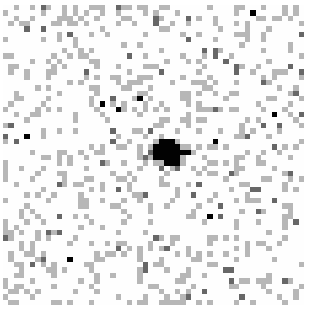


TIFF name: excised node 1_2 Interfile name: ME18_3
Image duration: 300 sec Start time: 15:06:51



TIFF name: excised node_3 Interfile name: ME18_4
Image duration: 300 sec Start time: 15:19:45

ME18



TIFF name: excised_4 Interfile name:ME18_5
Image duration: 300 sec Start time: 15:39:44

ME19

5x5 Patient: ME19

Date of Study: 08/04/03

Patient Initials:

Patient History: noticed lesion on her back about 3-4 months ago

Sex: F

Age: 61

Location of Tumor/Lesions: On back

Breslow Thickness: 2.8mm

Clark Level: IV

Surgeon: Murray

Images/Data of study:

Preop Images: GE 500 Emory nuclear medicine staff

OR Images: 5 x 5 gamma camera

Tissue Resected:

Neoprobe

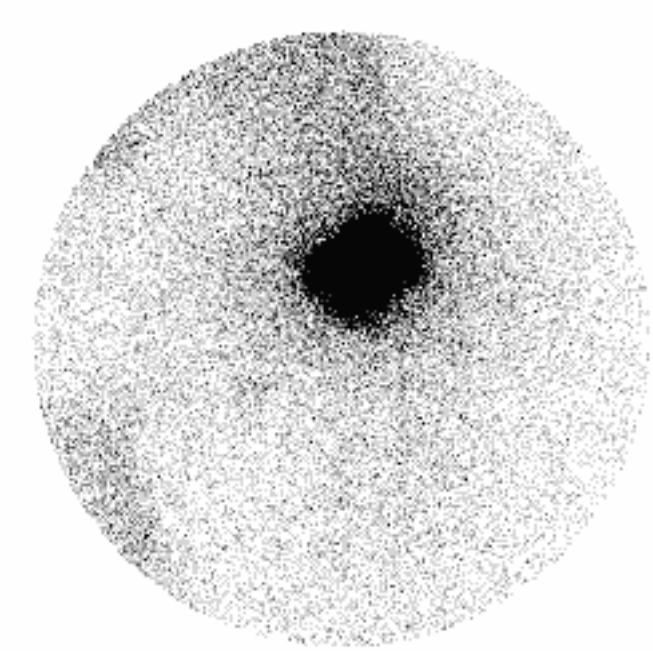
Sample ID	Indicator	Post-ex count	OR Img Activity	Location
1	Hot	844	110	mid level 1 rt axilla

Pathology: Hot SN #1 (1/6), non-blue, largest node measures 1.7 x 1.0 x 1.5 cm;

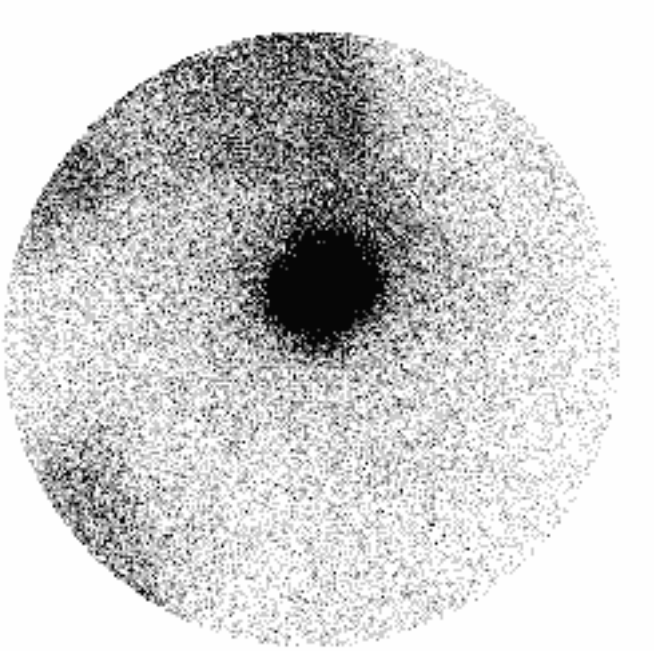
Comments/ Discussion: The melanoma is located (right mid interscapula thoracic region) was measured to be 2.8 mm by Emory. The patient was injected with 0.231 mCi of Tc99m sulfur colloid at 10:21. Surgery began at 5:30 pm . Out of the one node submitted for pathology there were a total of 6 sentinel nodes and there was 1 **positive** node. As a result of the positive node the subject returned for a completion of therapeutic right axillary lymphadectomy. There was nothing significant to note about this case. A total of 25 lymph nodes were examined and 0 were found to be positive.

ME19

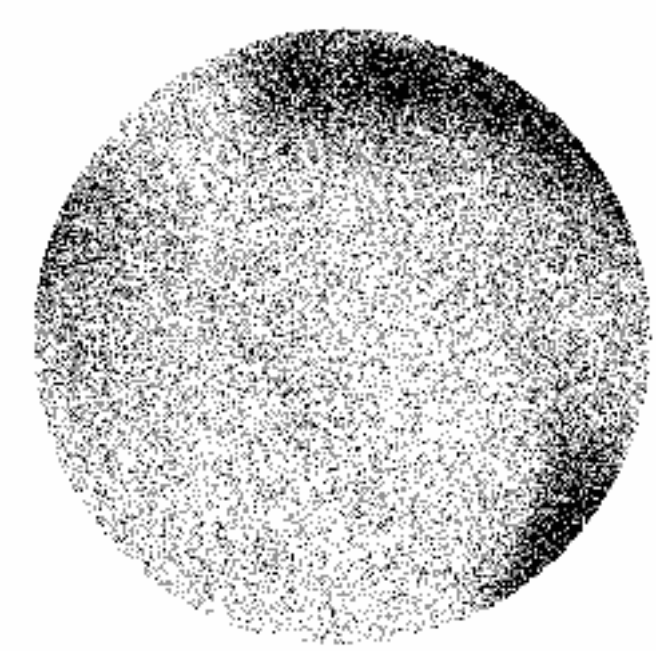
Preop Images



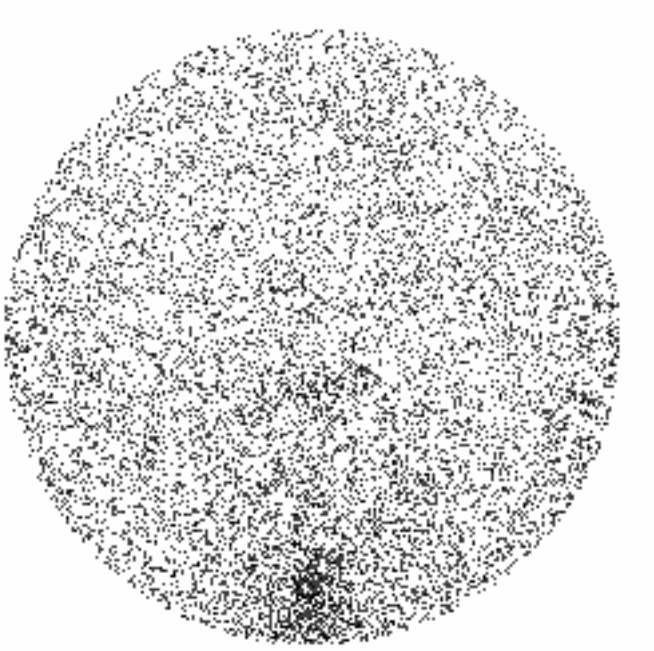
ANT 10MIN



ANT W_PULLED BREAST

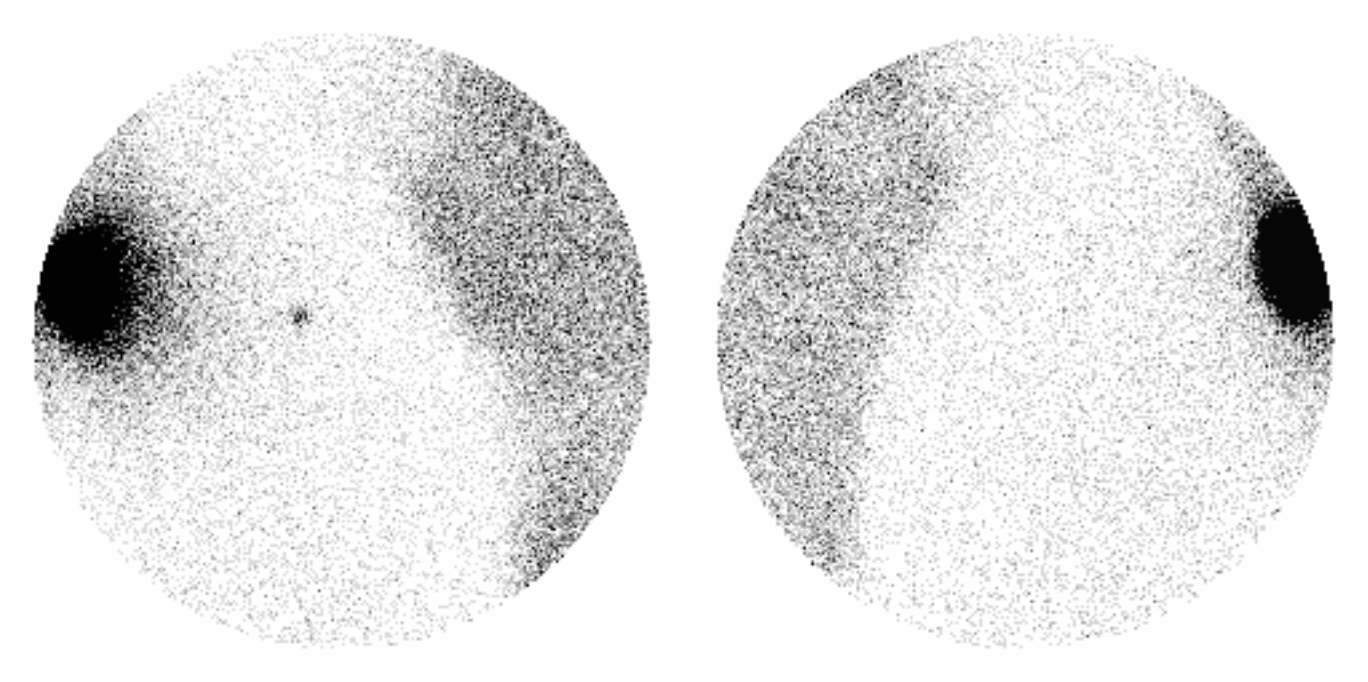


LTANT 35MIN



PEL 40MIN

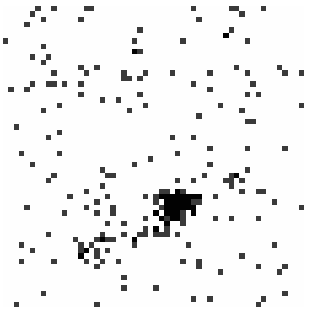
ME19



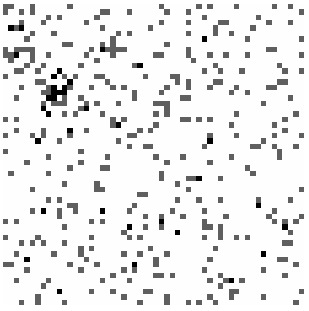
RTAX 50MIN **LTAX 55MIN**

OR Images

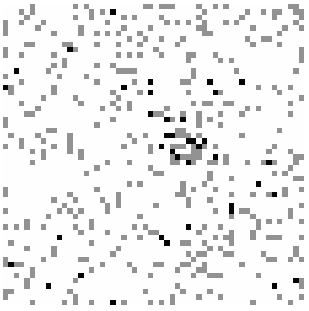
TIFF name:injection site Interfile name: ME19_2
Image duration: 70sec Start time: 17:19:48



TIFF name: injection site postexcision Interfile name:ME19_3
Image duration: 60 sec Start time: 18:20:39

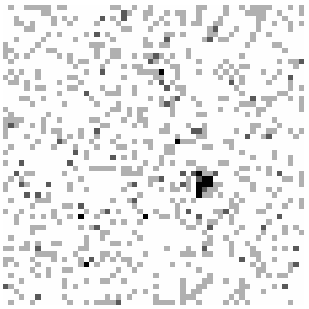


TIFF name: preincision nonsterile Interfile name: ME19_1
Image duration: 180 sec Start time: 18:33:19



TIFF name: postexcision Interfile name:ME19_4
Image duration: 180 sec Start time: 19:19:12

ME19



TIFF name: excised node Interfile name:ME19_5
Image duration: 300 sec Start time: 19:24:45

APPENDIX B

5x5 Patient: BR01

Date of Study: 12/20/01

Patient Initials: MC

Patient History:

Sex: F

Age: 78

Location of Tumor/Lesion: Left breast @3:00.

Surgeon: Murray

Images/Data of study:

Preop Images: GE 500 by Sandi

OR Images: 5 x 5 gamma camera

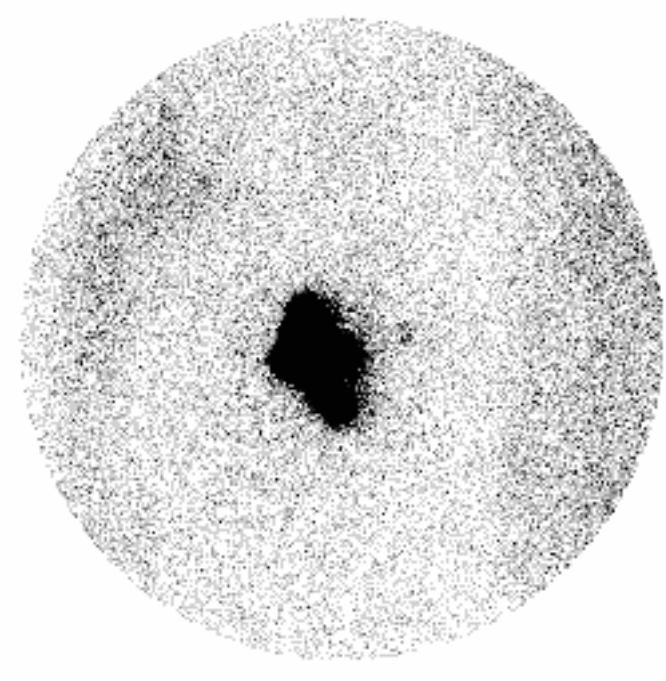
Tissue Resected:

Neoprobe

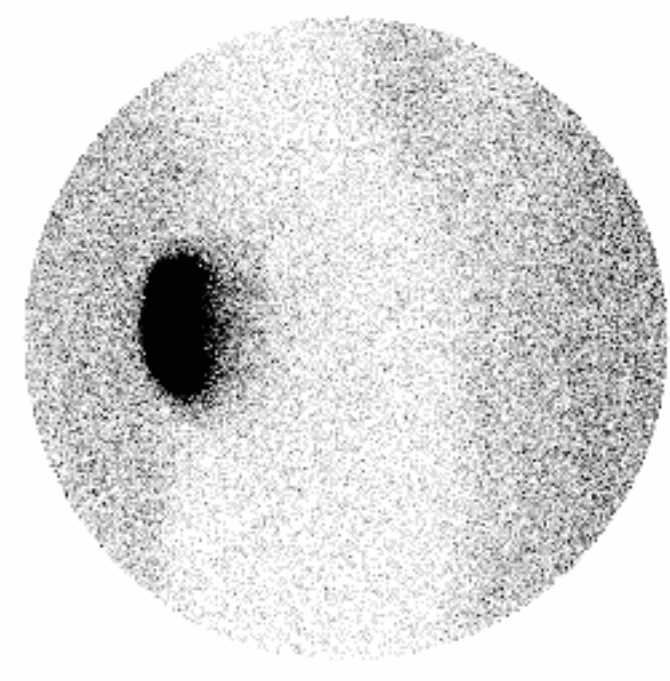
Sample ID	Indicators	Post-ex count	OR img activity	Location
1(SLN)	Hot/blue	215	88	Left axilla

Comments/Discussion: Apparent stronger focus in preoperative images actually flow of tracer along guidewire.

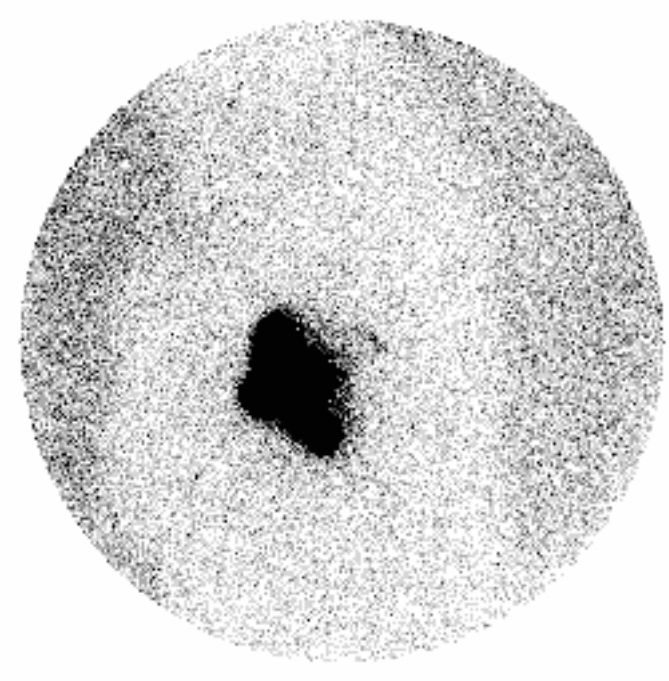
Preoperative Images



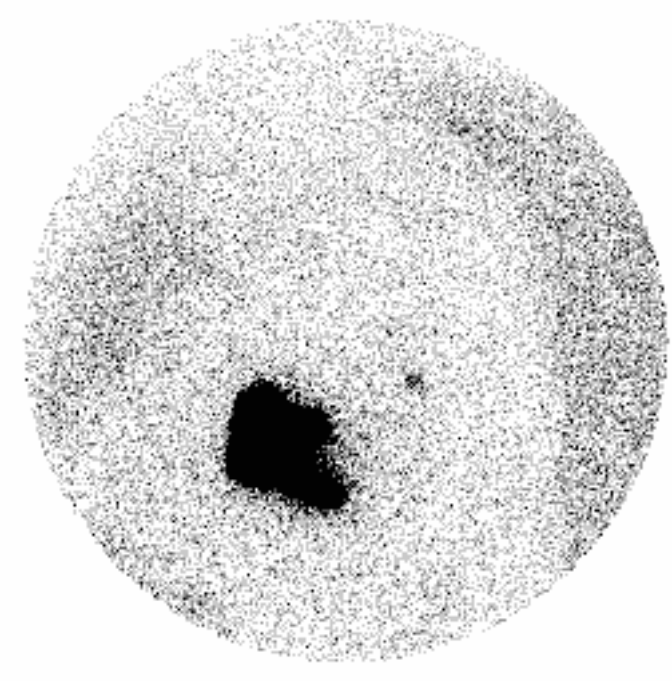
LAO 15MIN



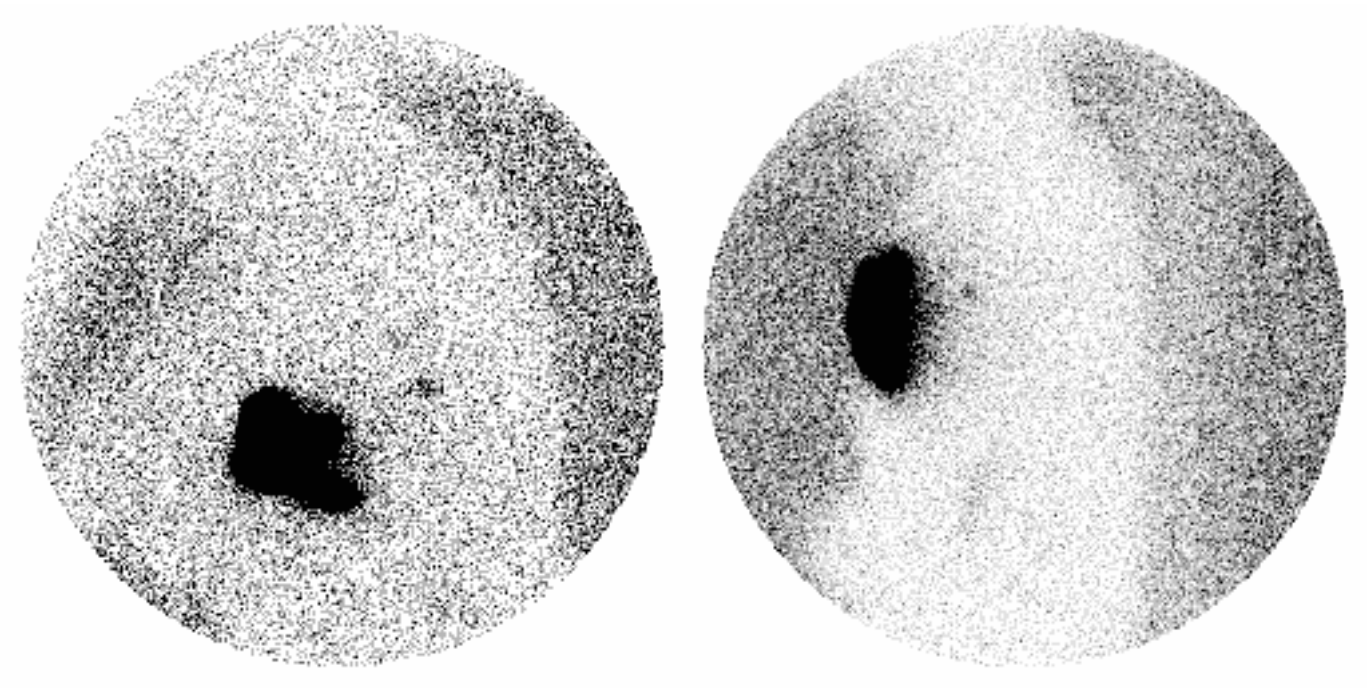
LTLAT AX 20MIN



LAO 25MIN

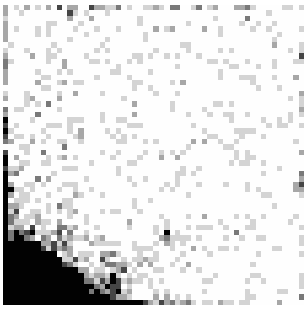


LAO ONSIDE 40MIN



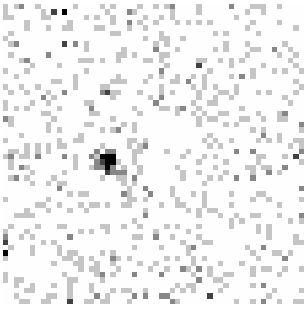
LAO ONSIDE 45MIN **LTLAT 1HR**

OR Images



TIFF name: preinc llat Interfile name: BR01_1
Image duration: 180 sec Start time: 16:30:24

First OR attempt; we don't seem to have positioned camera correctly!



TIFF name: node Interfile name: BR01_2
Image duration: 300 sec Start time: 17:06:00

Excised tissue

5x5 Patient: BR02

Date of Study: 01/05/02

Patient Initials: MO

Patient History:

Sex: F

Age:

Location of Tumor/Lesions: Right breast @ 3:00. Cup size: A

Surgeon: Styblo

Images/Data of study:

Preop Images: GE 500 by Sandi

OR Images: 5 x 5 gamma camera

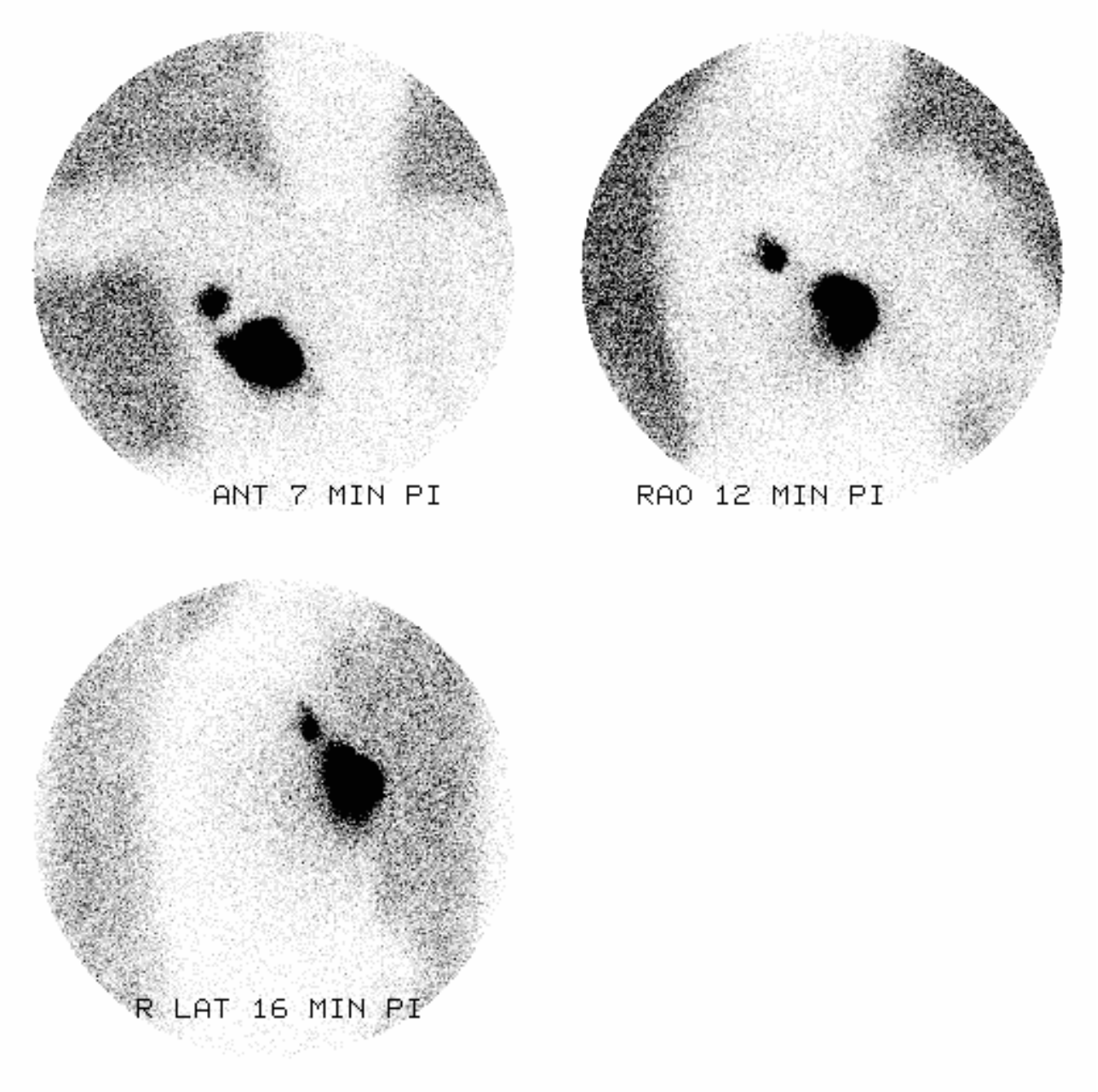
Tissue Resected:

C-Trak

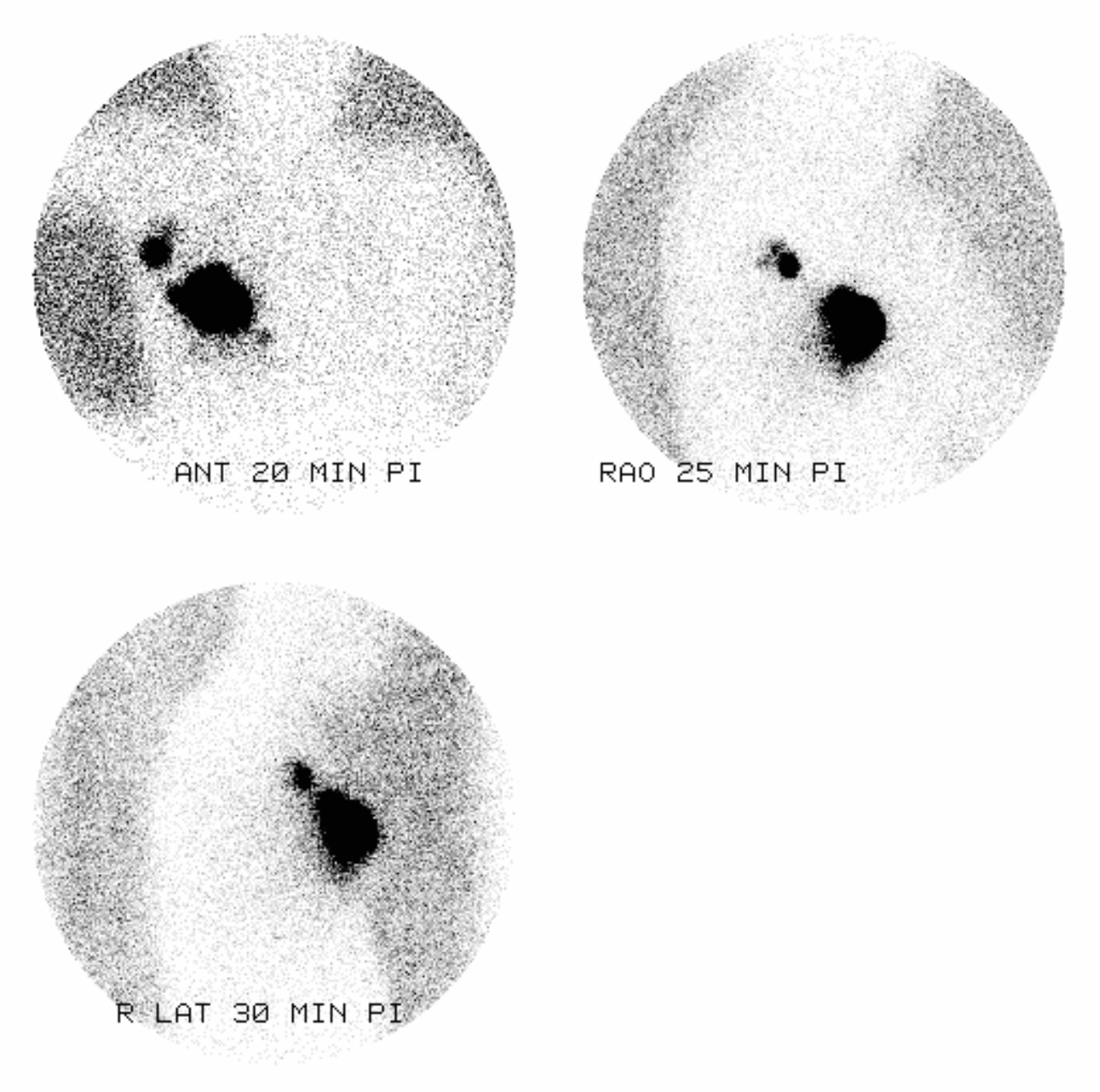
Sample ID	Indicators	Post-ex Counts	OR Image Activity	Location
1(SLN)	Hot/blue	7958	3735	Right axilla
2(SLN)	Hot	1262	404	Right axilla
3(SecLN)	Hot/blue	3190	461	Right axilla
4(SecLN)	Hot/blue	829	268	Right axilla
5(SecLN)	Hot	2085	301	Right axilla

BR02

Preoperative Images

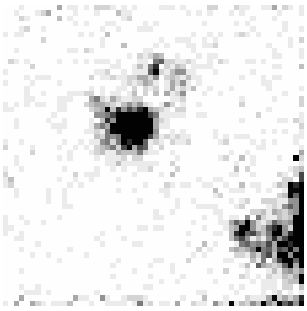


BR02

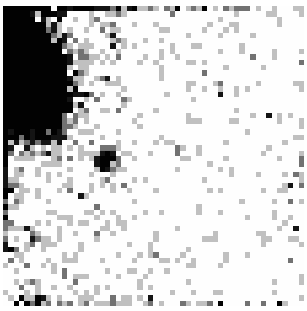


Secondary level axillary and internal mammary nodes now visualized

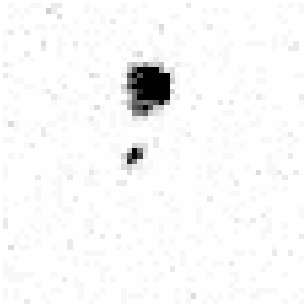
OR Images



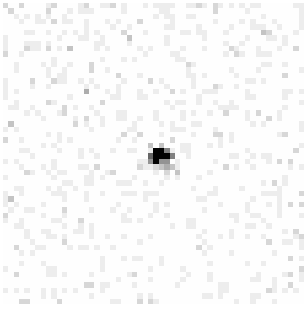
TIFF name: lao30 ax Interfile name: BR02_1
Image duration: 120 sec Start time: 14:20:21



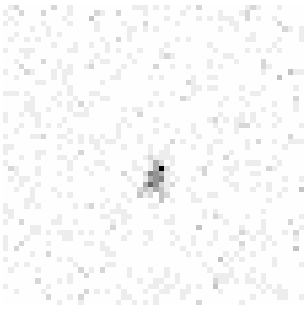
TIFF name: ant im Interfile name: BR02_2
Image duration: 120 sec Start time: 14:23:42



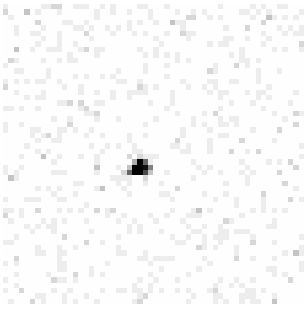
TIFF name: nodes1and2 Interfile name: BR02_3
Image duration: 180 sec Start time: 14:45:21



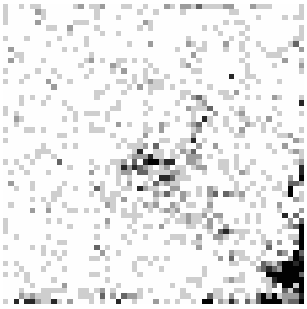
TIFF name: node3 Interfile name: BR02_4
Image duration: 180 sec Start time: 14:49:08



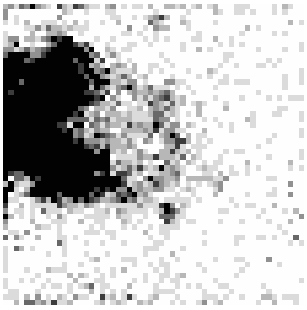
TIFF name: node4 Interfile name: BR02_4
Image duration: 180 sec Start time: 14:54:23



TIFF name: node5 Interfile name: BR02_4
Image duration: 180 sec Start time: 14:57:48

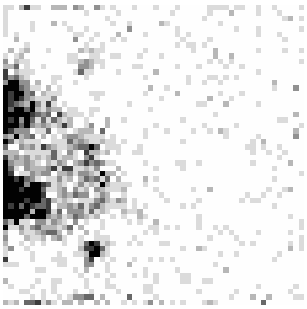


TIFF name: lao45 ax postex Interfile name: BR02_5
Image duration: 180 sec Start time: 15:02:32



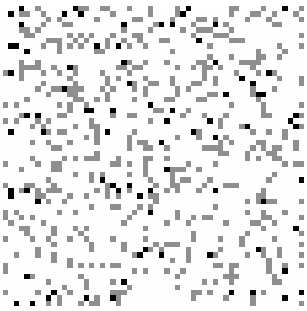
TIFF name: ant im postlump1 Interfile name: BR02_6
Image duration: 144 sec Start time: 15:43:24

See split inj site, im node… imaged by enthusiastic surgeon using "her camera"



TIFF name: ant im postlump2 Interfile name: BR02_6
Image duration: 120 sec Start time: 15:46:05

Repositioning…



TIFF name: node im Interfile name: BR02_7
Image duration: 180 sec Start time: 16:06:13

Where did it go???

BR03

5x5 Patient: BR03

Date of Study: 01/16/02

Patient Initials: IL

Patient History:

Sex: F

Age: 54

Location of Tumor/Lesions: Left breast @ 2:00. Cup size:C

Surgeon: Styblo

Images/Data of study:

Preop Images: GE 500 by Sandi

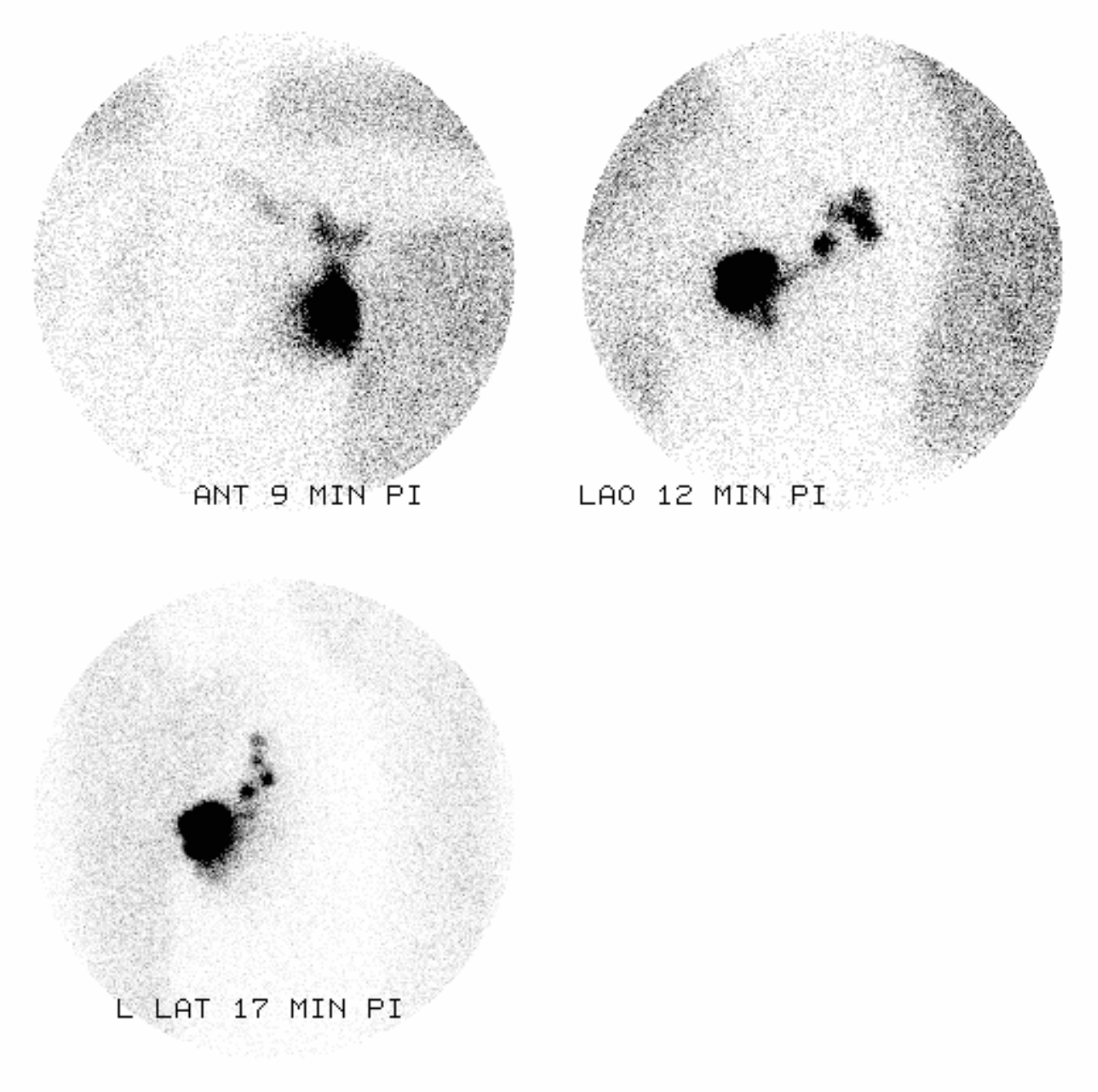
OR Images: 5 x 5 gamma camera

Tissue Resected:

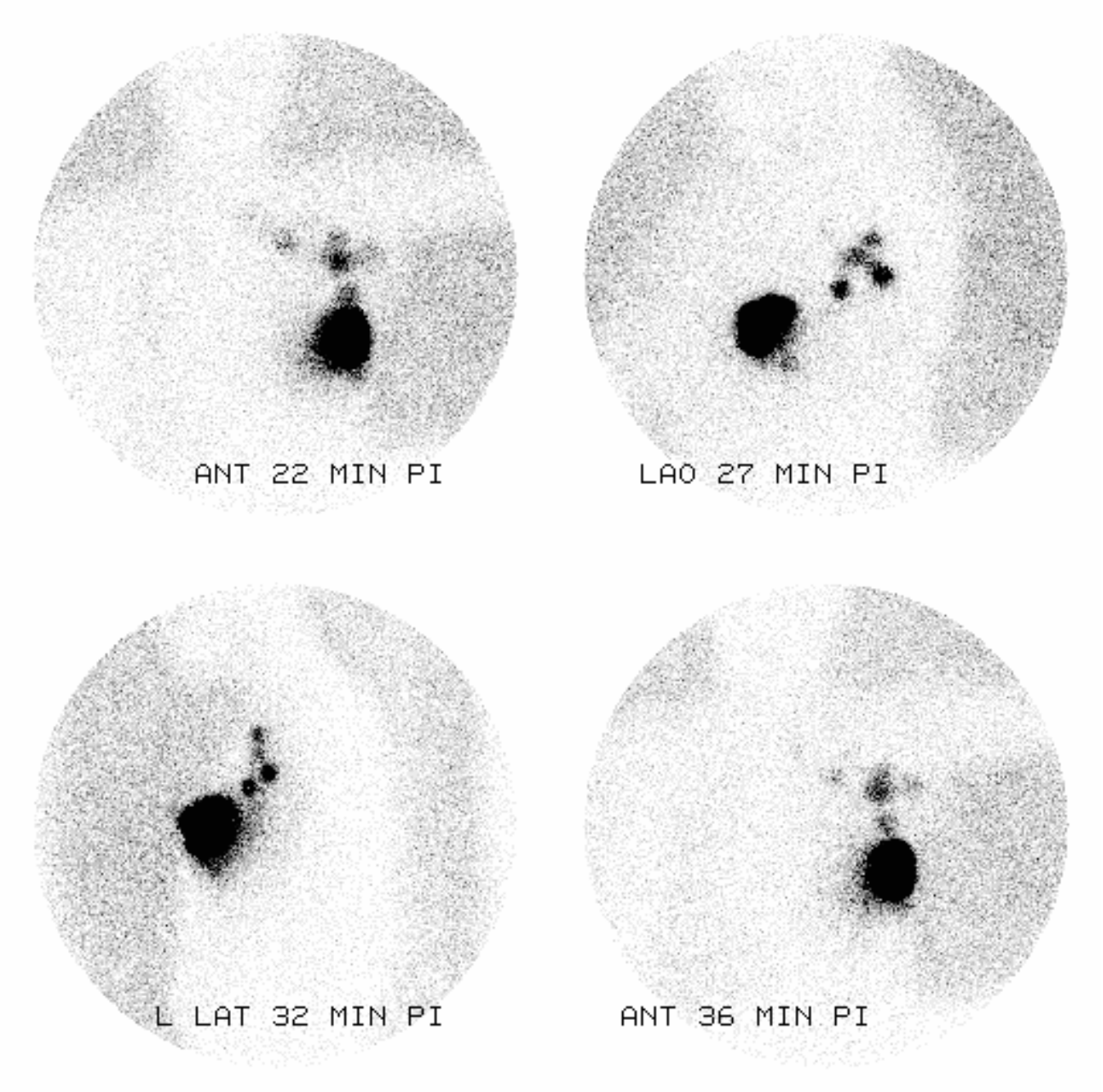
C-Trak

Sample ID	Indicators	Post-ex Counts	OR Image Activity	Location
1(SLN)	Hot	4913	720	Axillary
2(SLN)	Hot	1850	182	Axillary
3(SLN)	Hot	362	72	Axillary
4(SLN)	Hot	4501	511	Axillary
5(SLN)	Hot	3003	325	Axillary
6(Axcont)		No counts	111	Axillary
7(SLN)	Hot	1045	523	Left SN
8(PecLN)	Hot/blue	3739	NA	Pectoral Node

Preoperative Images

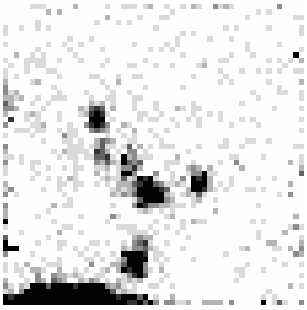


BR03

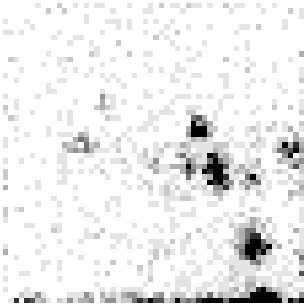


That’s a lot of nodes!

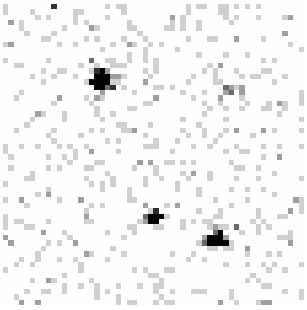
OR Images



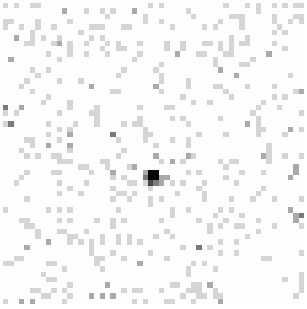
TIFF name: lao45 ax Interfile name: BR03_1
Image duration: 120 sec Start time: 14:24:11



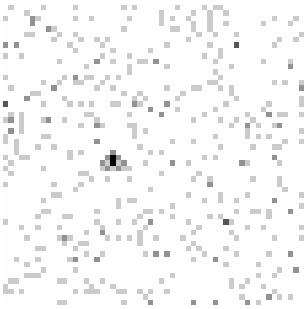
TIFF name: ant ax Interfile name: BR03_2
Image duration: 120 sec Start time: 14:29:07



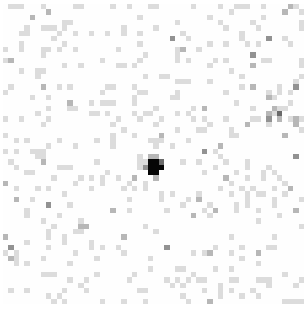
TIFF name: nodes1-4 Interfile name: BR03_3
Image duration: 120 sec Start time: 15:08:49



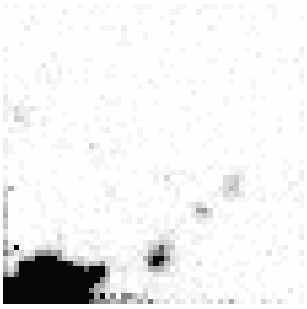
TIFF name: node5 Interfile name: BR03_4
Image duration: 124 sec Start time: 15:11:53



TIFF name: node6 Interfile name: BR03_5
Image duration: 119 sec Start time: 15:27:24

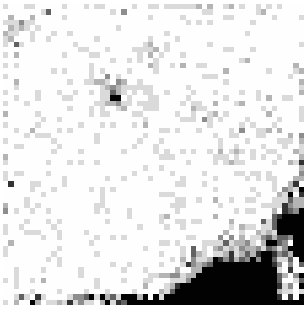


TIFF name: node7 Interfile name: BR03_6
Image duration: 120 sec Start time: 15:25:53



TIFF name: lao45 ax postex Interfile name: BR03_7
Image duration: 120 sec Start time: 15:29:39

Camera position (angle wrt body) changed from “lao45 ax”…



TIFF name: ant ax postex Interfile name: BR03_8
Image duration: 120 sec Start time: 15:32:41

5x5 Patient: BR04

Date of Study: 01/23/02

Patient Initials: JS

Patient History:

Sex: F

Age: 40

Location of Tumor/Lesions: Right breast @ 9:00. Cup size:D

Surgeon: Styblo

Images/Data of study:

Preop Images: GE 500 by Sandi

OR Images: 5 x 5 gamma camera

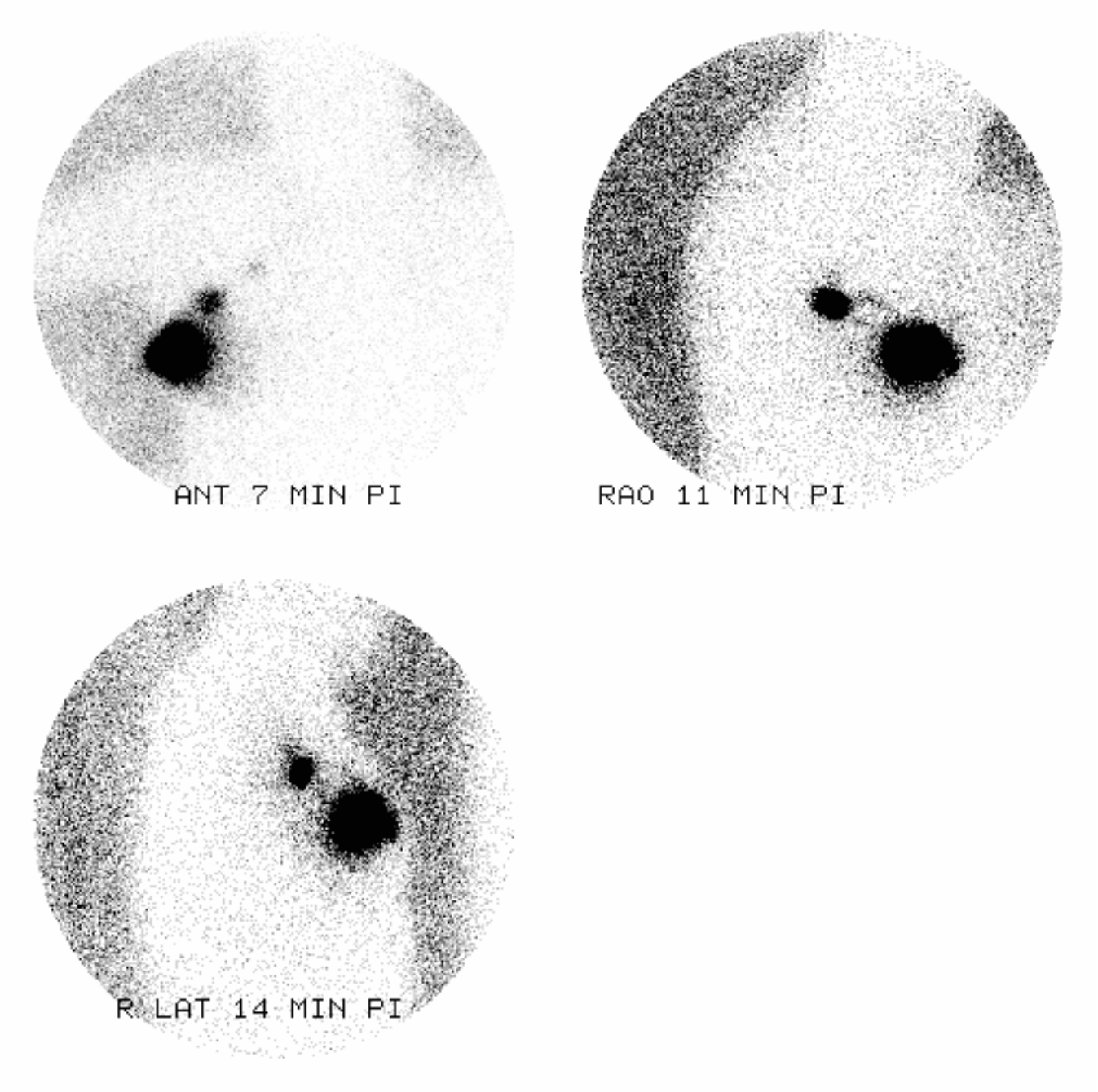
Tissue Resected:

C-trak

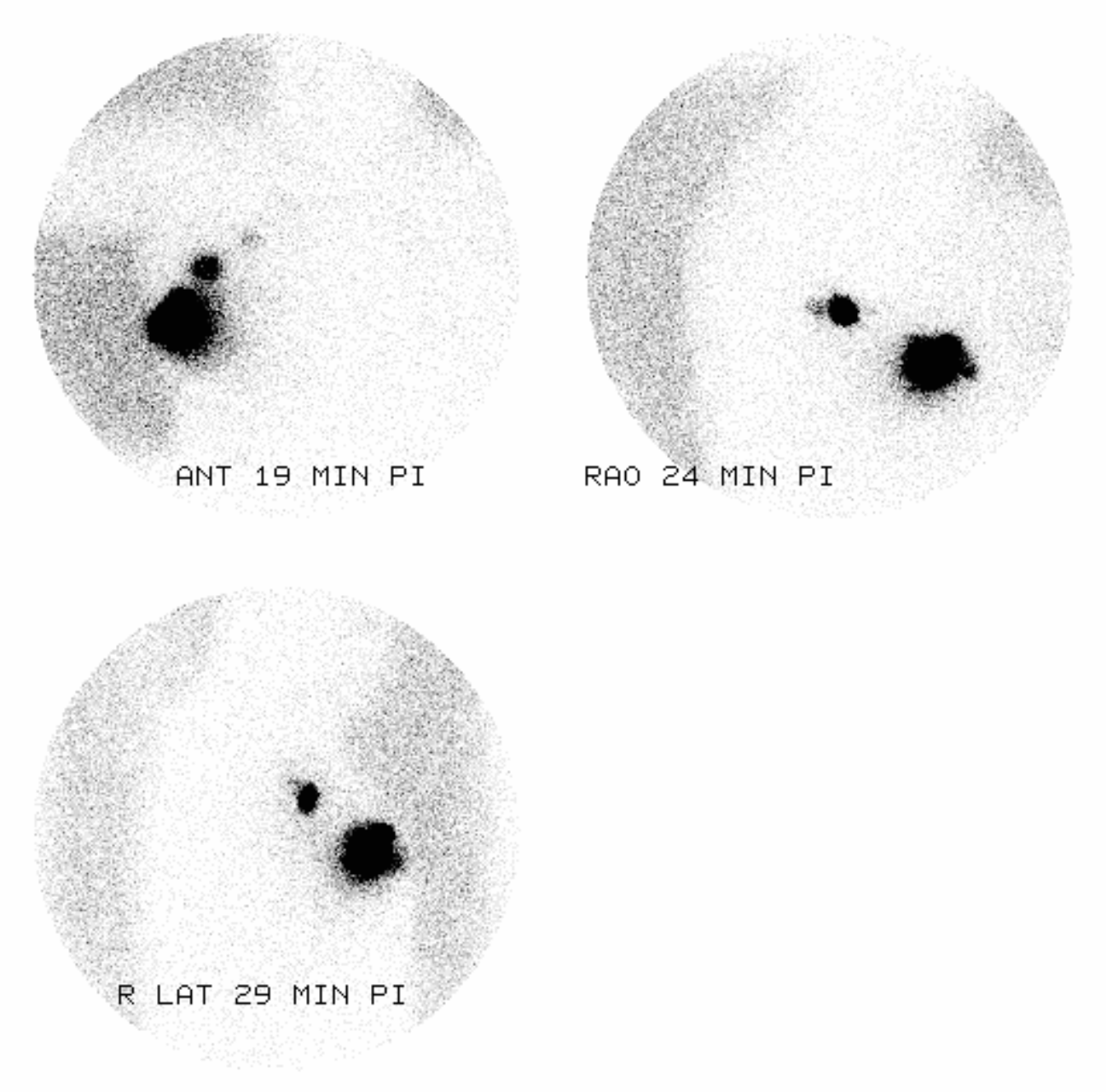
Sample ID	Indicators	Post-ex Counts	OR Image Activity	Location
1(SLN)	Hot/blue	15333	12988	axillary

BR04

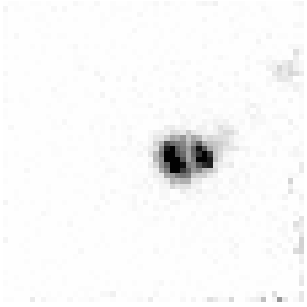
Preoperative Images



BR04

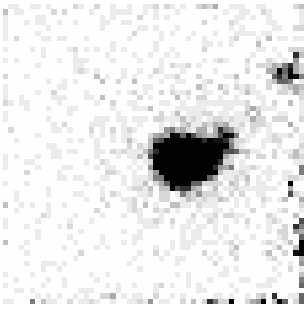


OR Images



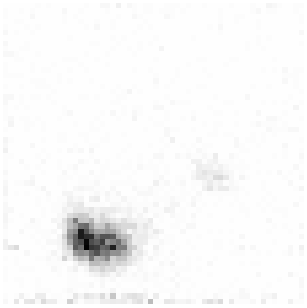
TIFF name: lao45 ax wind1 Interfile name: BR04_1
Image duration: 180 sec Start time: 11:08:03

Two nodes closely spaced can be seen with this display windowing.

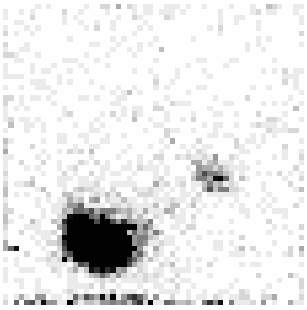


TIFF name: lao45 ax wind2 Interfile name: BR04_1
Image duration: 180 sec Start time: 11:08:03

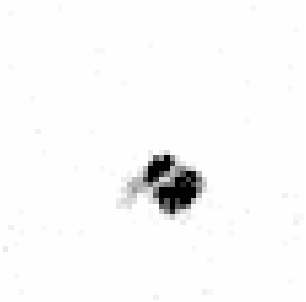
Windowing display to reveal smaller-activity foci obscures above-referenced structure.



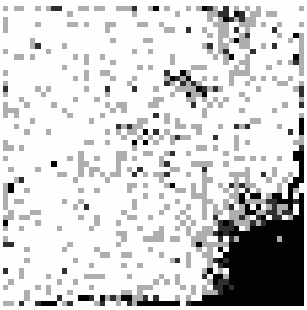
TIFF name: ant ax wind1 Interfile name: BR04_1
Image duration: 180 sec Start time: 11:12:31



TIFF name: ant ax wind2 Interfile name: BR04_1
Image duration: 180 sec Start time: 11:12:31



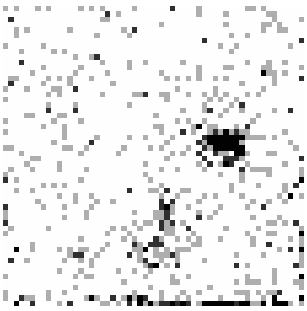
TIFF name: nodes Interfile name: BR04_2
Image duration: 120 sec Start time: 11:46:25



TIFF name: ant ax postex bed Interfile name: BR04_2
Image duration: 120 sec Start time: 11:51:04

Windowed to show very low levels of activity.

TIFF name: [aborted] Interfile name: BR04_2
Image duration: 31 sec Start time: 11:53:58



TIFF name: ant ax postex sec Interfile name: BR04_2
Image duration: 120 sec Start time: 11:55:54

Camera repositioned to show secondary node not excised.

5x5 Patient: BR05

Date of Study: 02/25/02

Patient Initials: MS

Patient History:

Sex: F

Age:

Location of Tumor/Lesions: Left breast @ 2:00. Cup size: D

Surgeon: Styblo

Images/Data of study:

Preop Images: GE 500 by Sandi

OR Images: 5 x 5 gamma camera

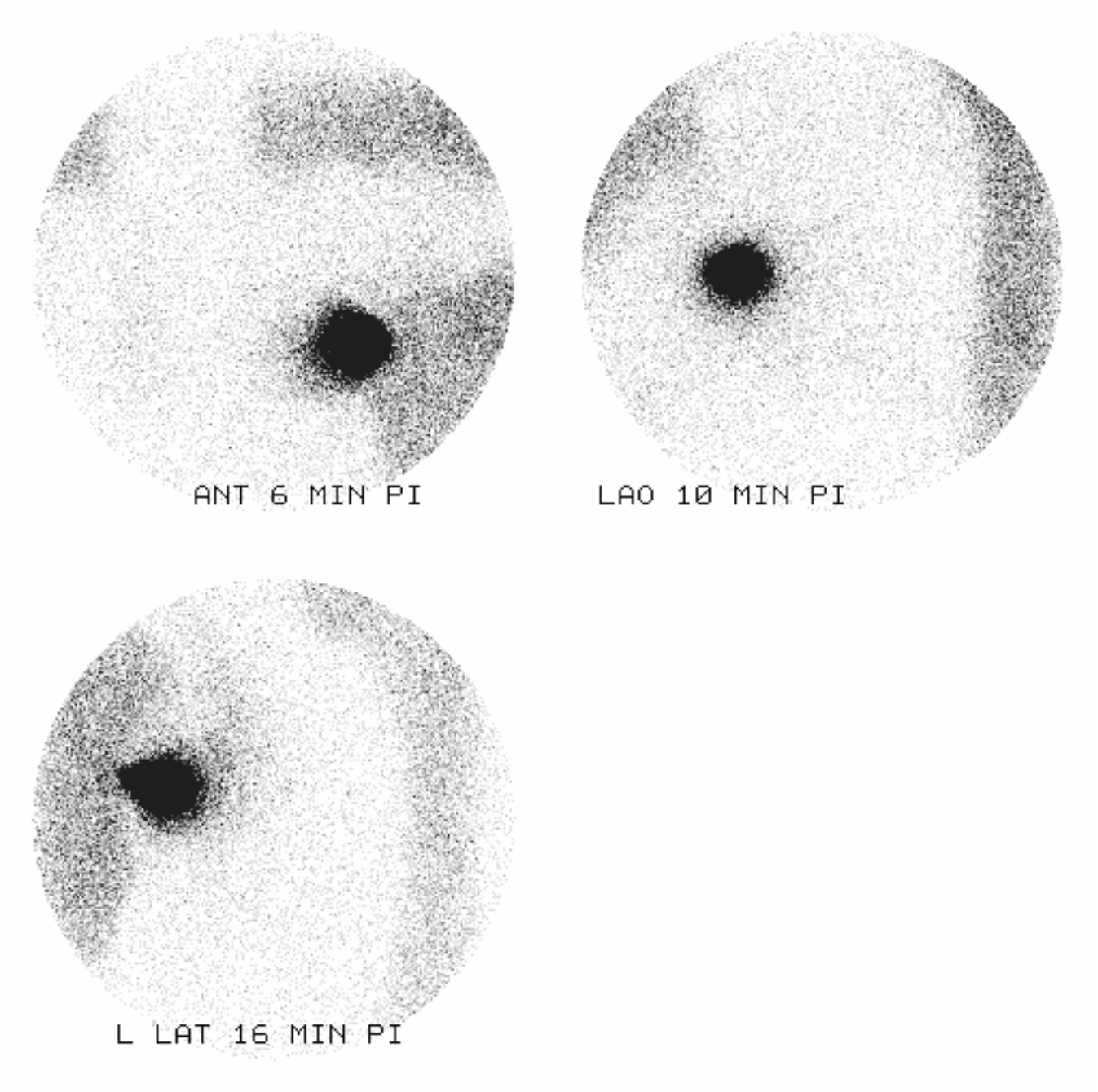
Tissue Resected:

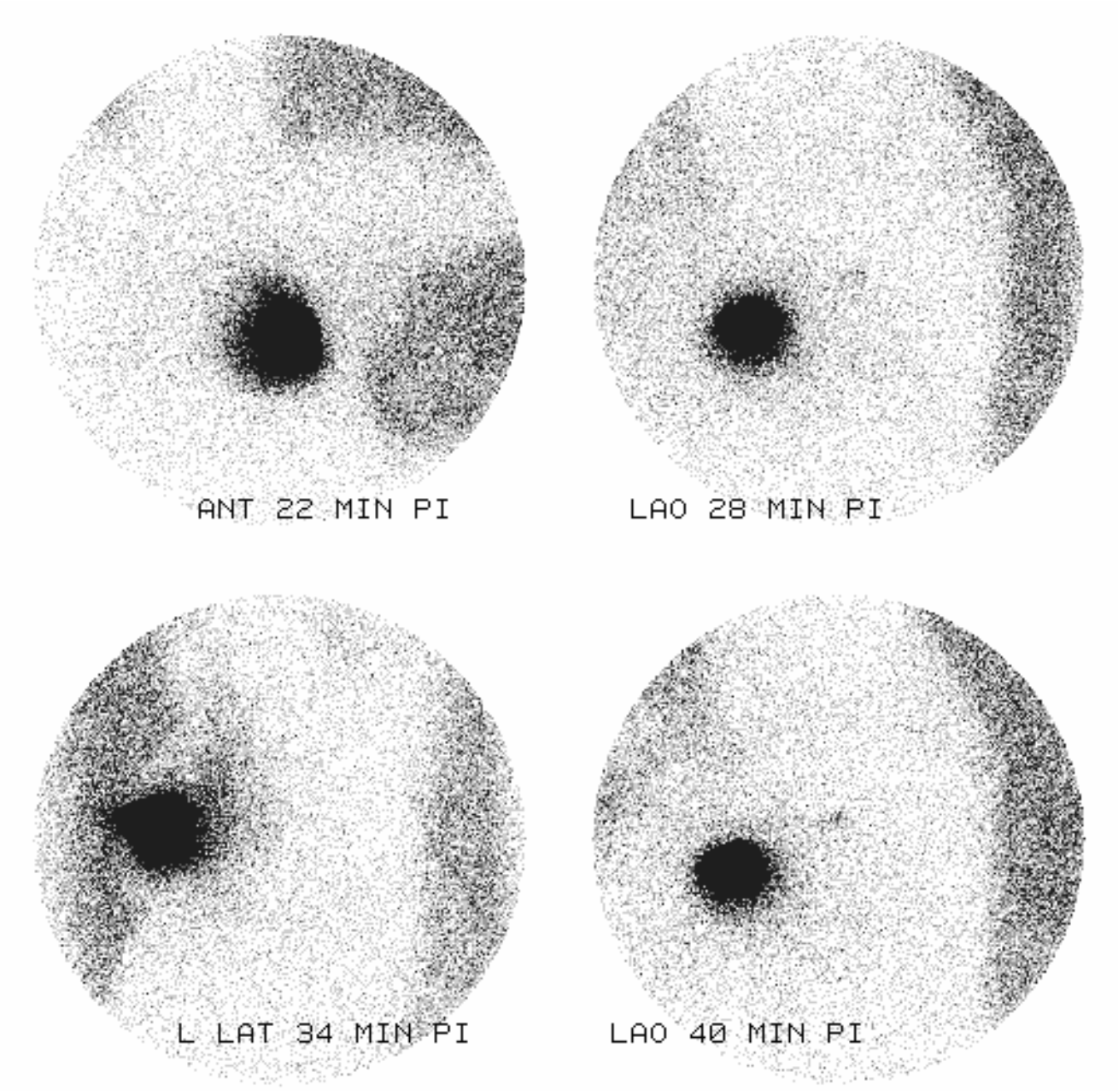
C-Trak

Sample ID	Indicators	Post-ex Counts	OR Image Activity	Location
1(SLN)	Hot	1300	186	Axillary
2(SLN)	Hot	272	24	Axillary
3(AxN)	Hot	105	NA	Axillary

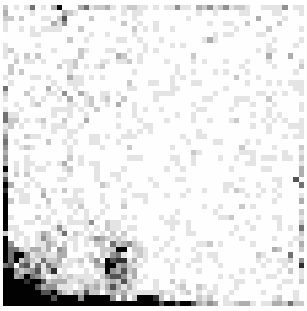
Comments/Discussion: ***LHEX collimator used (named "SQRH" to avoid system crash!)***

Preoperative Images

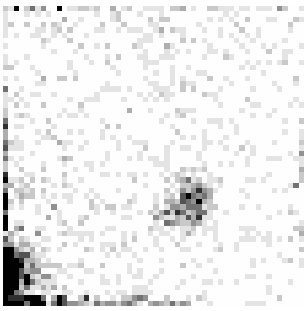



ANT 22 MIN PI
LAO 28 MIN PI
L LAT 34 MIN PI
LAO 40 MIN PI

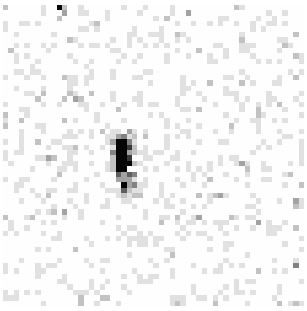
OR Images



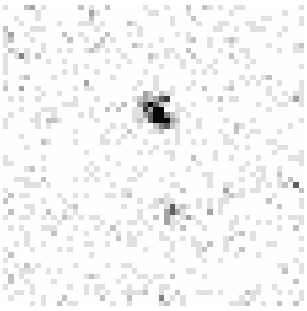
TIFF name: lao45 ax1 Interfile name: BR05_preinc
Image duration: 180 sec Start time: 14:06:13



TIFF name: lao45 ax2 Interfile name: BR05_preinc
Image duration: 180 sec Start time: 14:11:11



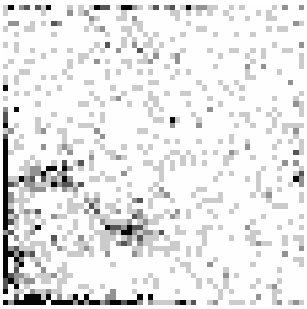
TIFF name: nodes Interfile name: BR05_nodes
Image duration: 180 sec Start time: 14:38:17



TIFF name: nodes sep Interfile name: BR05_nodes
Image duration: 180 sec Start time: 14:43:08

Nodes in previous specimen image physically separated and reimaged.

BR05



TIFF name: lao45 ax postex Interfile name: BR05_postex
Image duration: 180 sec Start time: 14:48:52

5x5 Patient: BR06

Date of Study: 02/25/02

Patient Initials: JM

Patient History:

Sex: F

Age: 58

Location of Tumor/Lesions: Right breast @ 2:00. Cup size: C

Surgeon: Styblo

Images/Data of study: GE 500 by Sandi

Preop Images: 5 x5 gamma camera

OR Images:

Tissue Resected:

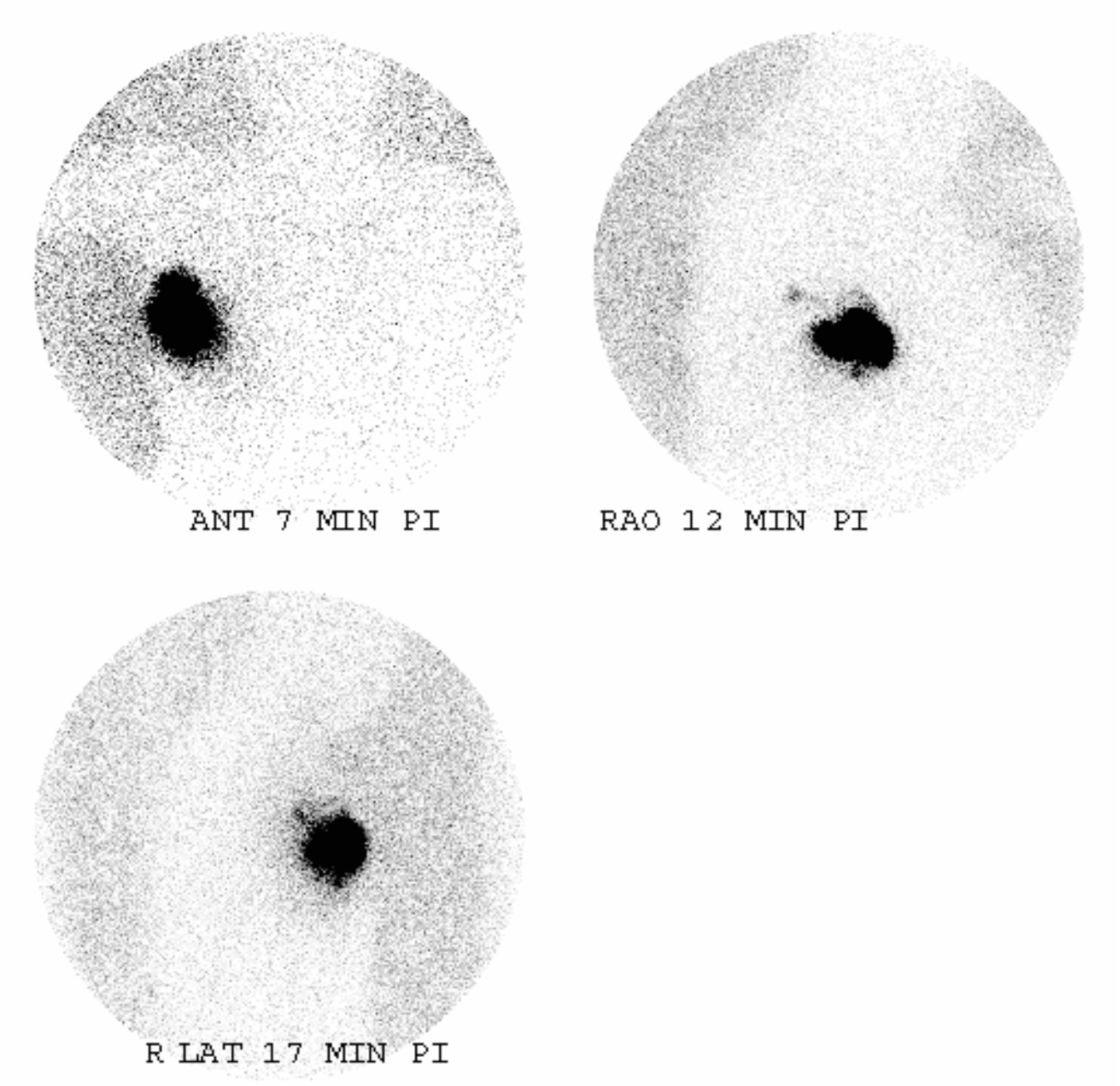
C-Trak

Sample ID	Indicators	Post-ex Counts	OR Image Activity	Location
1(SLN)	Hot/blue	1894	2124	Axillary
2(SecLN)	Hot/blue	386	105	axillary

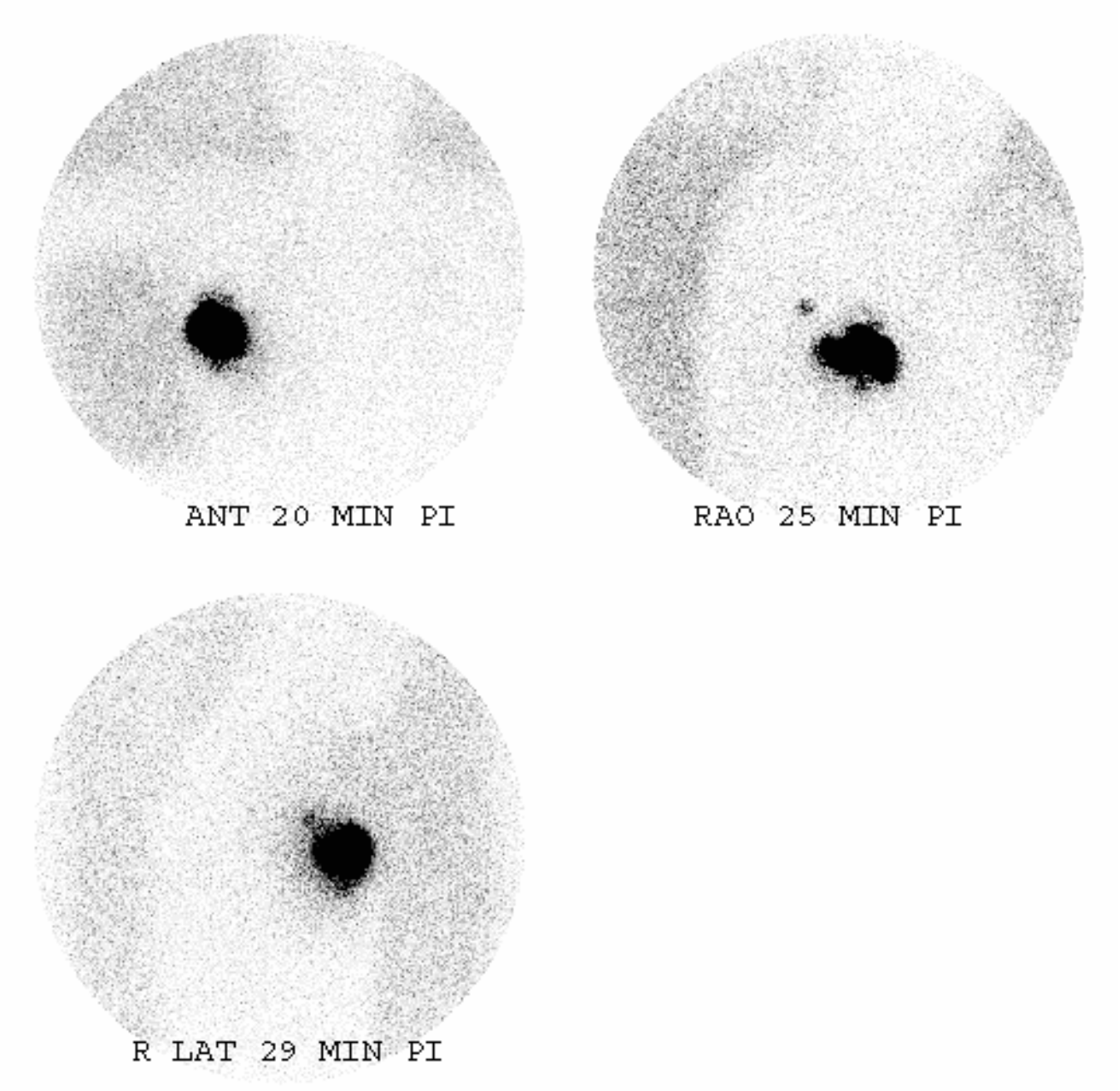
Comments/Discussion: ***LHEX collimator used (named "SQRH" to avoid system crash!)***

BR06

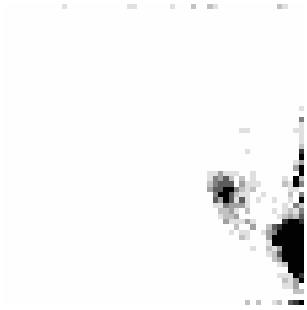
Preoperative Images



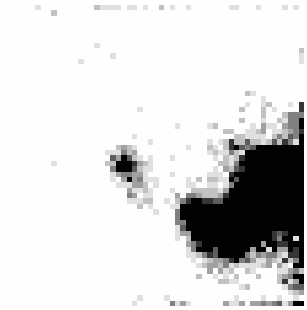
BR06



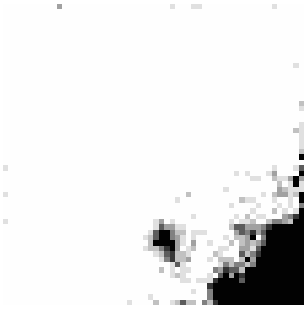
OR Images



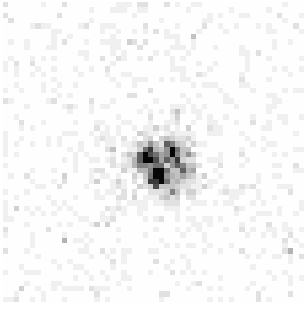
TIFF name: lao45 ax1 Interfile name: BR06_preinc
Image duration: 150 sec Start time: 15:49:30



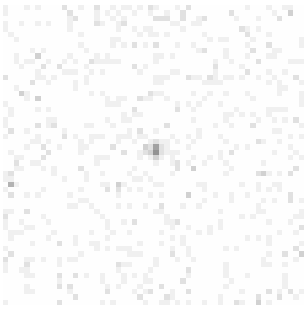
TIFF name: lao45 ax2 Interfile name: BR06_preinc
Image duration: 150 sec Start time: 15:53:32



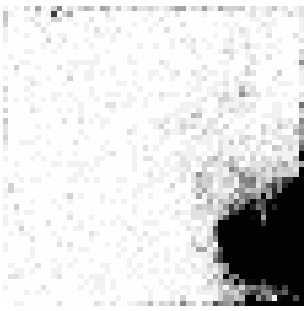
TIFF name: lao45 ax3 Interfile name: BR06_preinc
Image duration: 150 sec Start time: 15:56:56



TIFF name: node1 Interfile name: BR06_nodes
Image duration: 180 sec Start time: 16:31:13



TIFF name: node2 Interfile name: BR01_nodes
Image duration: 180 sec Start time: 16:37:54



TIFF name: lao ax postex Interfile name: BR06_postex
Image duration: 180 sec Start time: 16:42:43

5x5 Patient: BR07

Date of Study: 11/04/02

Patient Initials: RM

Patient History: Both grandmother's and aunt died from breast cancer.

Sex: F

Age: 47

Location of Tumor/Lesion:.left breast @ 2:00

Surgeon: Styblo

Images/Data of study:

Preop Images: GE500 and 5x5 camera by Sandi

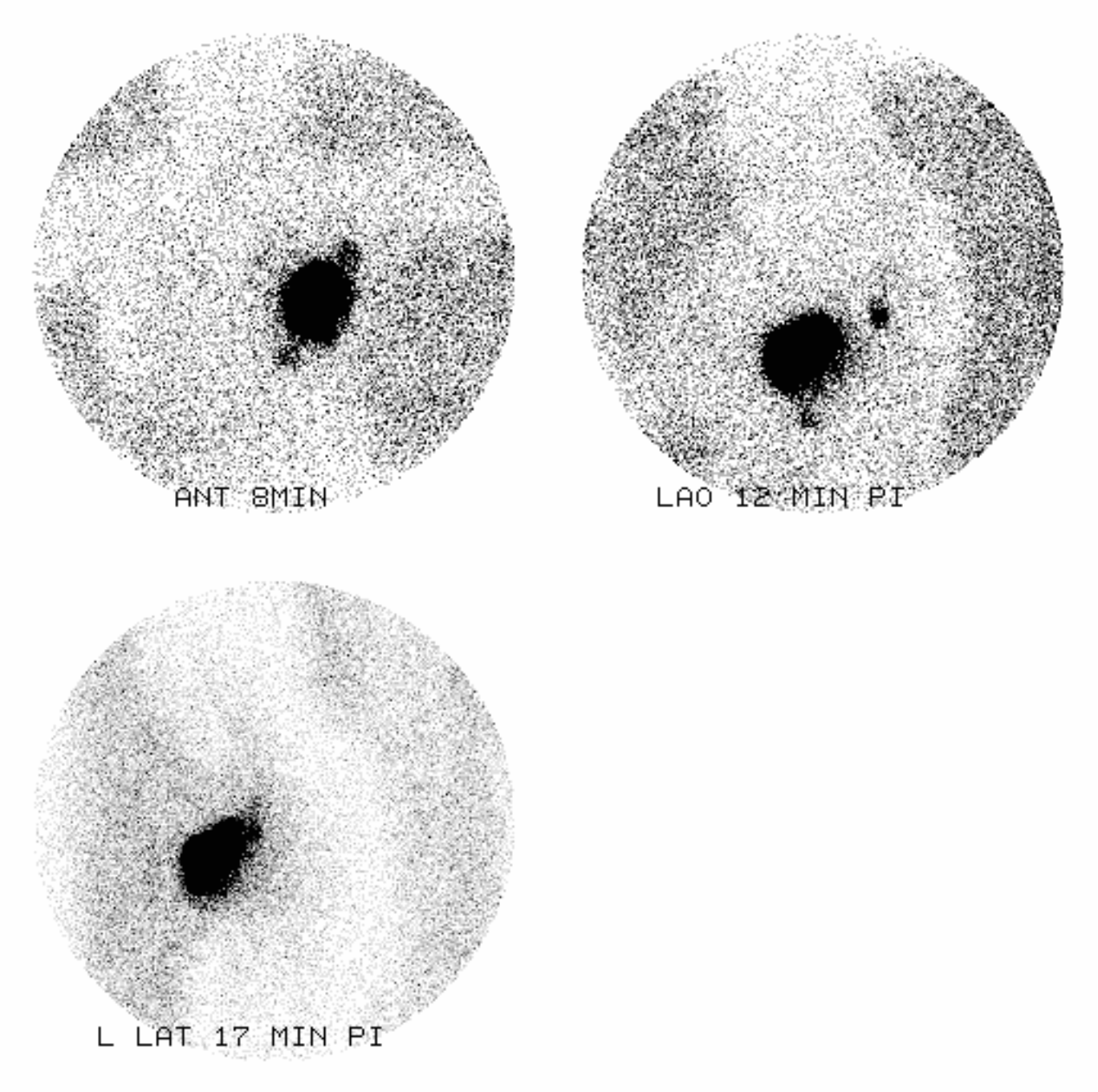
OR Images: None, probe only

Tissue Resected:

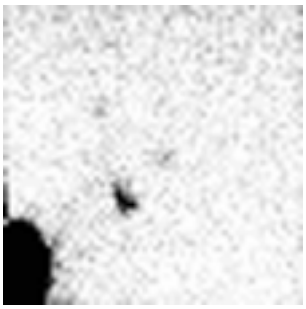
C-Trak

Sample ID	Indicators	Post-ex count	OR img activity	Location
1	Hot/Blue	4153	NA	Lft axilla
2	Hot/Blue	850	NA	Lft axilla
3	Hot/Blue	1328	NA	Lft axilla
4(axill node)	Hot/Blue	301	NA	Lft axilla
5(axill node)	Blue	36	NA	Lft axilla

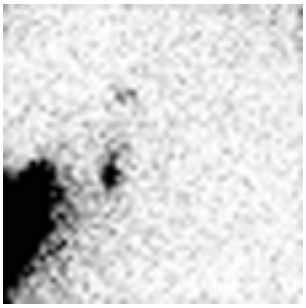
Preoperative Images



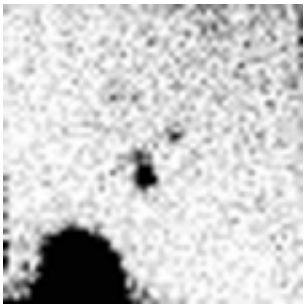
5x5 Images



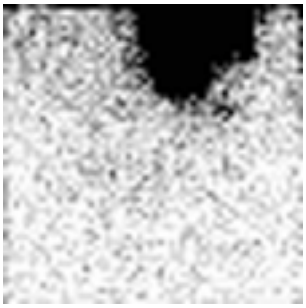
TIFF name: slnsurvey_1 ANT Interfile name: BR07_1
Image duration: 300 sec Start time: 11:37:08



TIFF name: slnsurvey_2 left Interfile name: BR07_2
Image duration: 300 sec Start time: 11:49:45



TIFF name: slnsurvey_3 ANT Interfile name:BR01_3
Image duration: 300 sec Start time: 11:57:34



TIFF name: slnsurvey_4 ANT Interfile name: BR07_4
Image duration: 180 sec Start time: 12:04:34

5x5 Patient: BR08

Date of Study: 11/19/02

Patient Initials: BB

Patient History:

Sex: F

Age:

Location of Tumor/Lesion:.right breast

Surgeon: Styblo

Images/Data of study:

Preop Images: GE500 and 5x5 camera by Sandi

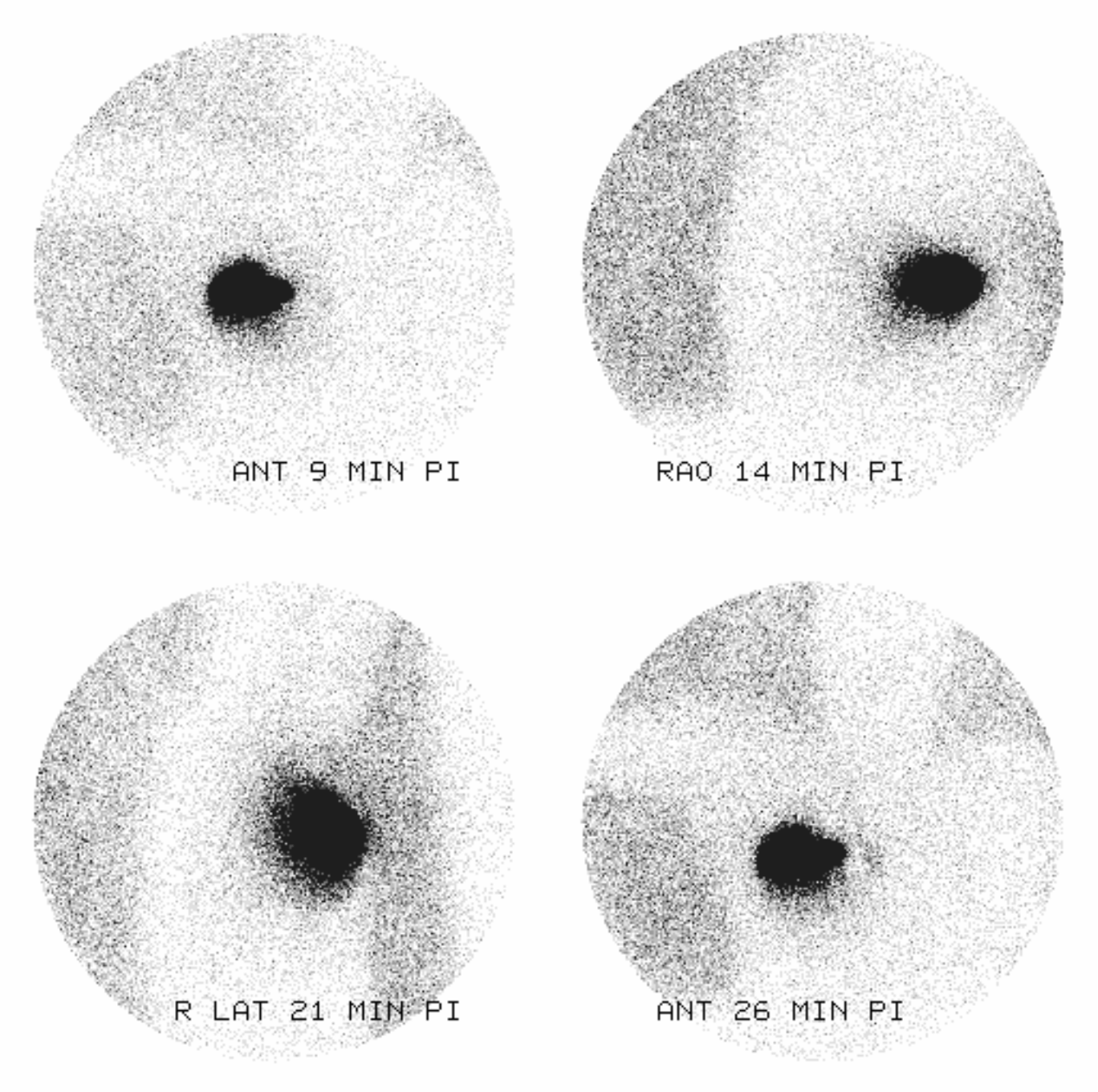
OR Images: None, probe only

Tissue Resected:

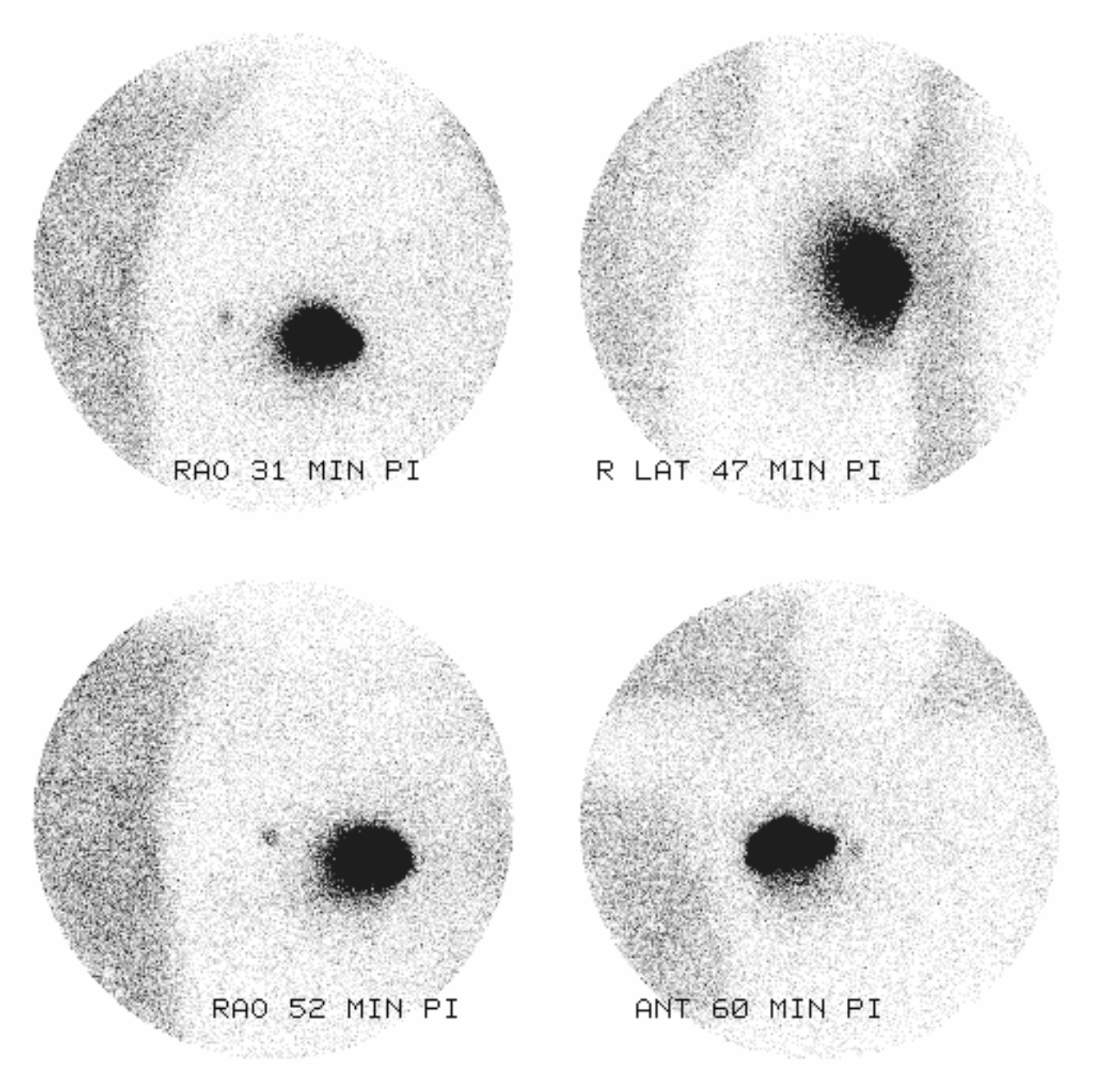
C-Trak

Sample ID	Indicators	Post-ex count	OR img activity	Location
1	Hot/Blue	1447	NA	Rt axilla

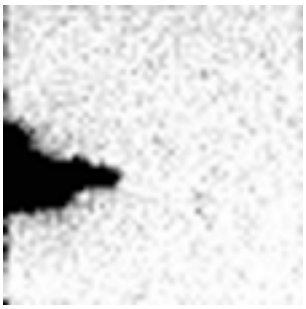
Preoperative Images



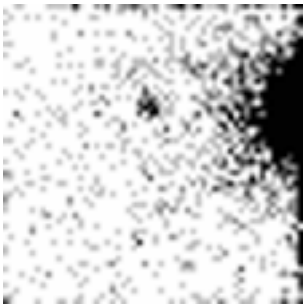
BR08



5x5 Images



TIFF name: slnsurvey_1 ANT Interfile name: BR08_1
Image duration: 200 sec Start time: 09:02:42



TIFF name: slnsurvey_2 RAO Interfile name: BR08_2
Image duration: 200sec Start time: 08:55:22

Comments/Discussion:
Timing for Dr. Styblo
10:58 Probe start
11:00 axillary count, pre-inc 692
11:06 axillary incision
11:09 mass #1 excised
11:12 incision probe
11:13 search, last count and stop

5x5 Patient: BR09

Date of Study: 03/12/03

Patient Initials: MH

Patient History: 58 year old nonpalpable. Excisional biopsy 2/7/03

Sex: F

Age: 58

Location of Tumor/Lesion:.left breast @ 2:00

Surgeon: Styblo

Images/Data of study:

Preop Images: GE500 and 5x5 camera by Sandi

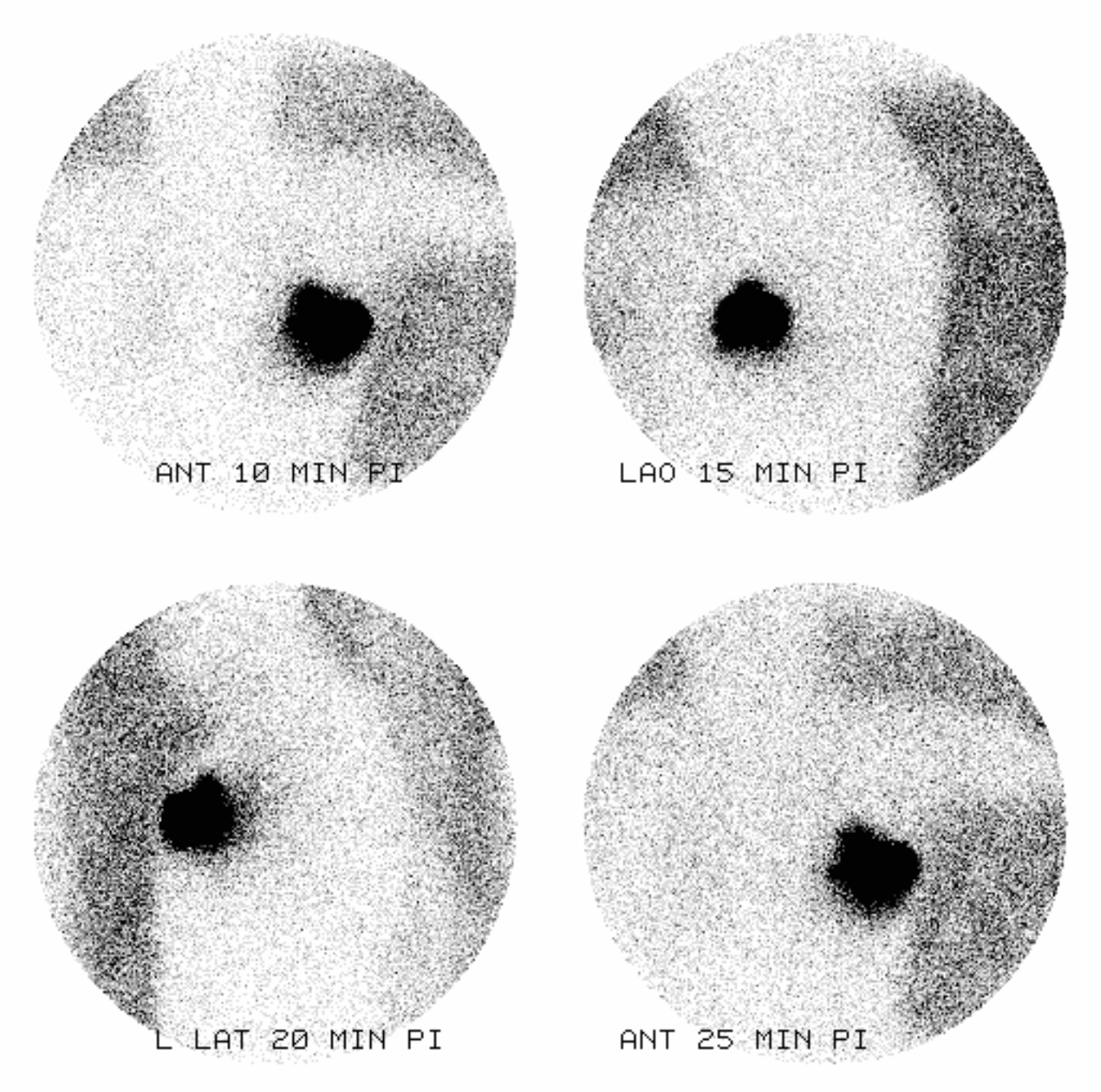
OR Images: 5 x 5 gamma camera

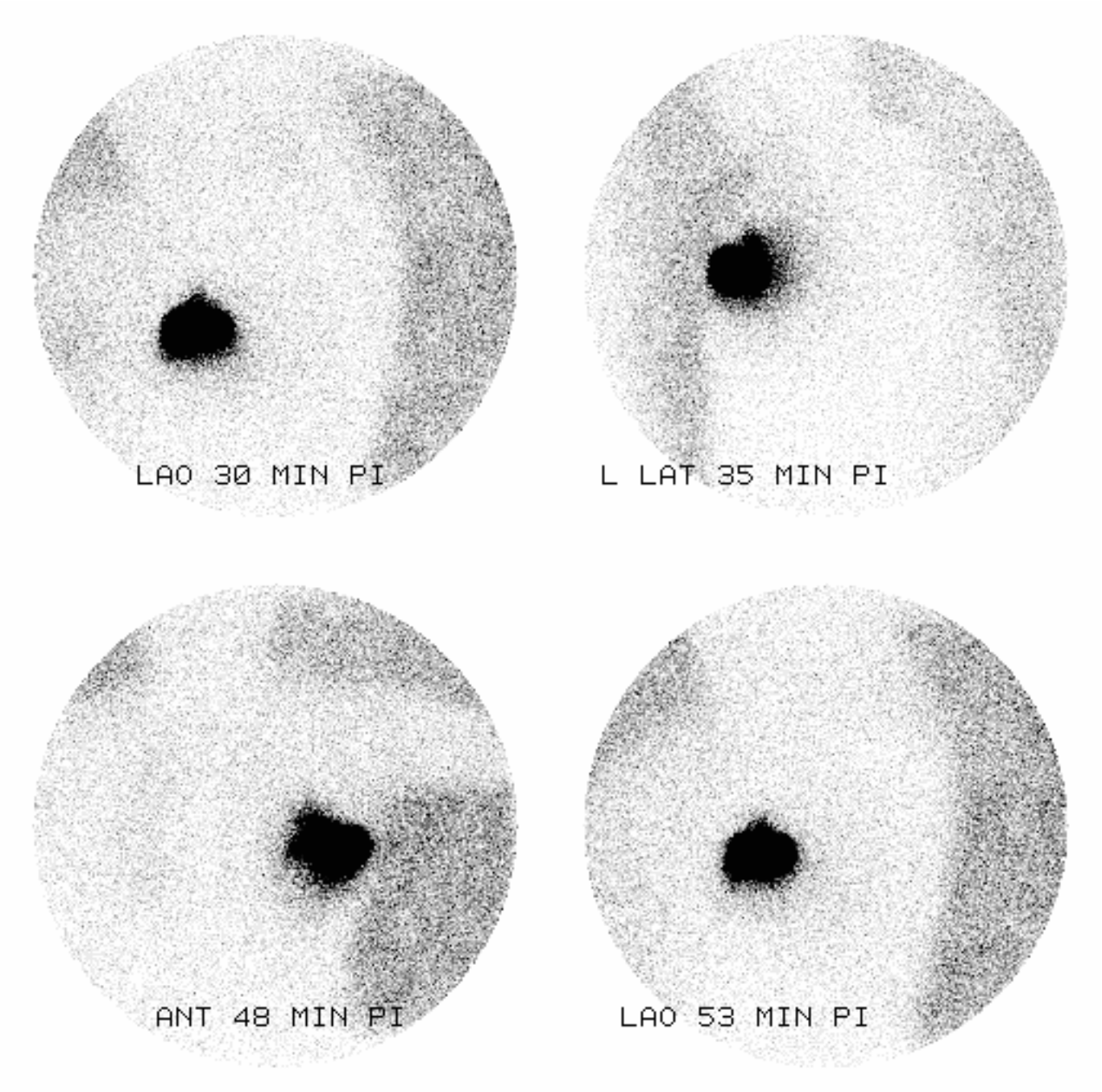
Tissue Resected:

C-Trak

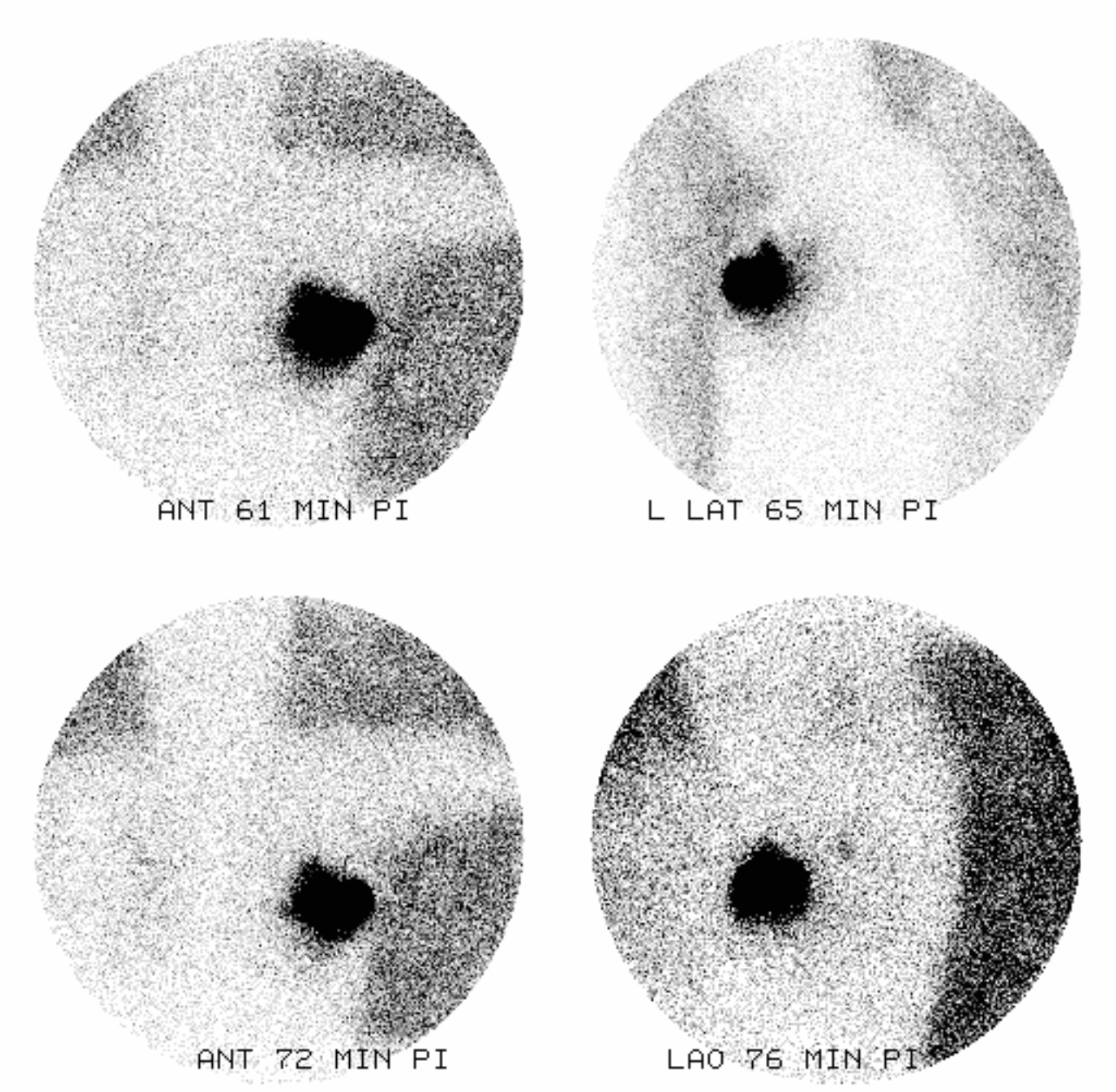
Sample ID	Indicators	Post-ex count	OR img activity	Location
1	Hot/Blue	1447	249	axilla

Preoperative Images



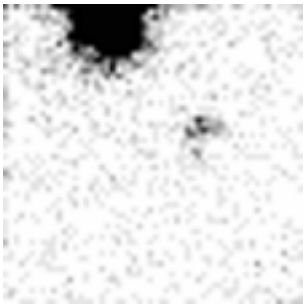

LAO 30 MIN PI
L LAT 35 MIN PI
ANT 48 MIN PI
LAO 53 MIN PI

BR09

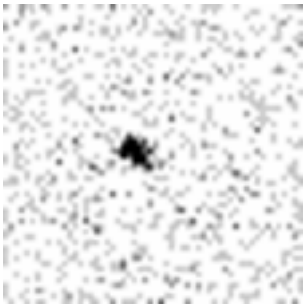


5x5 Images

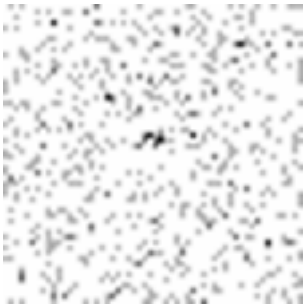
TIFF name: preincision_1 Interfile name: BR09
Image duration: 90 sec Start time: 11:20:14



TIFF name: preincision_2 Interfile name: BR09
Image duration: 300sec Start time: 11:23:22

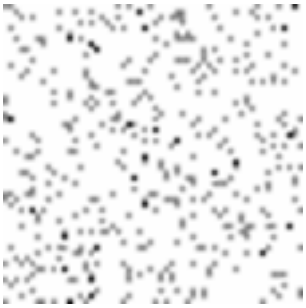


TIFF name: postexcision Interfile name: BR09
Image duration: 300sec Start time: 11:44:29



TIFF name: postexcision_2 Interfile name: BR09
Image duration: 180sec Start time: 11:54:09

BR09



TIFF name: contents Interfile name: BR09
Image duration: 120sec Start time: 11:58:53

BR09

Pathology:

Comments/Discussion:
Timing for Dr. Styblo
11:21-Start probe search
11:24-First count background
11:25-Counting node ,Dificulties positioning
11:31-Acquired image 1, attempted to count where probe counts were detected . Used q-tip tracer to locate via Sandi’s location
11:35-Image 2
11:42-Recounting
11:42-Surgeriy starts
11:52-Counting excised nodes, Image 3:node1
12:05-Image 4:node 2
12:12-Image 5:Contents

BR10

5x5 Patient: Br10

Date of Study: 03/17/03

Patient Initials: BM

Patient History: Partial mastectomy in right breast, sentinel node palpable by patient & doctor

Sex: F

Age: 80

Location of Tumor/Lesion: Right breast 8:30, ≈1.7cm

Surgeon: Styblo

Images/Data of study:

Preop Images: GE500 by Sandi

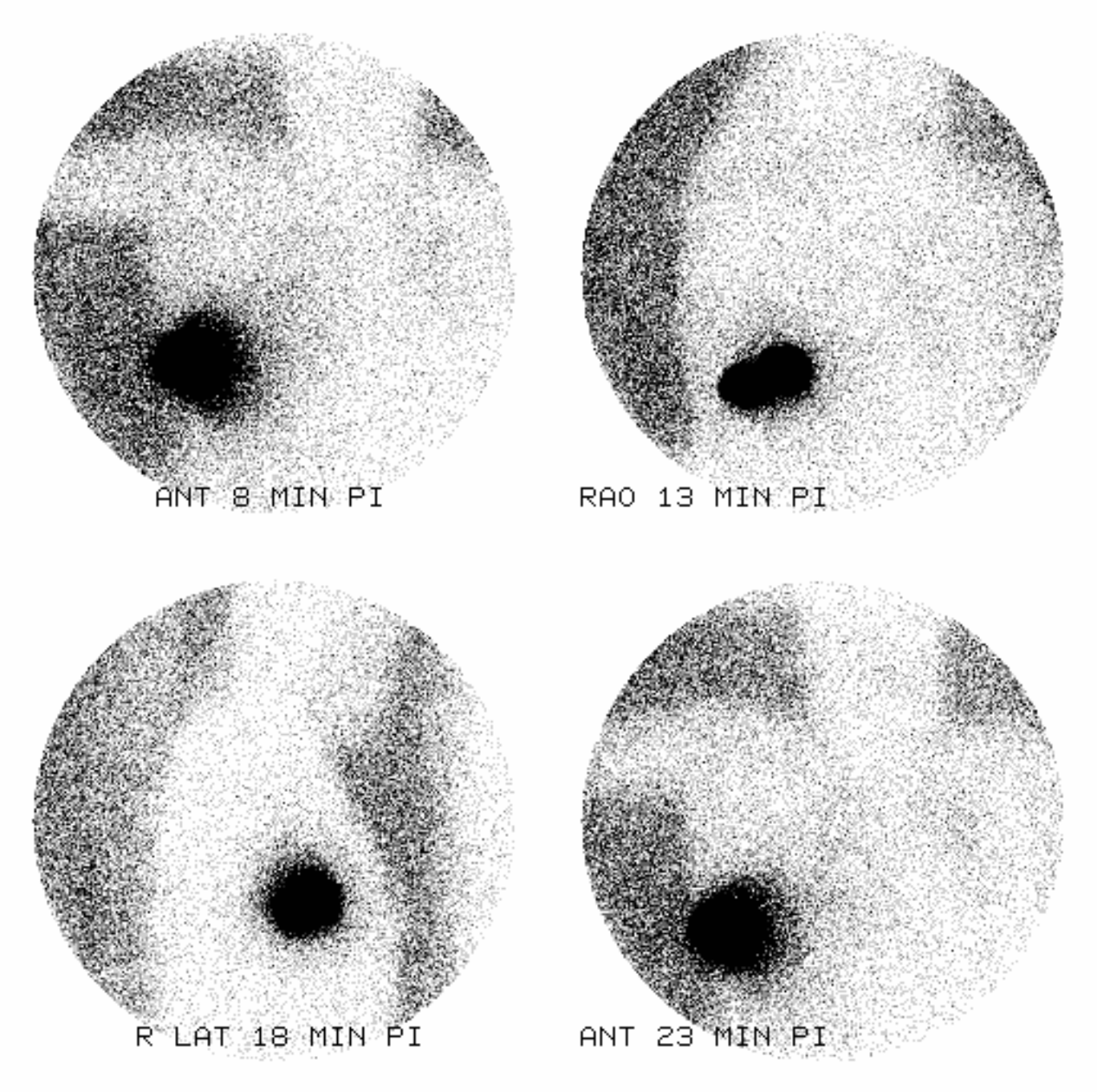
OR Images: none

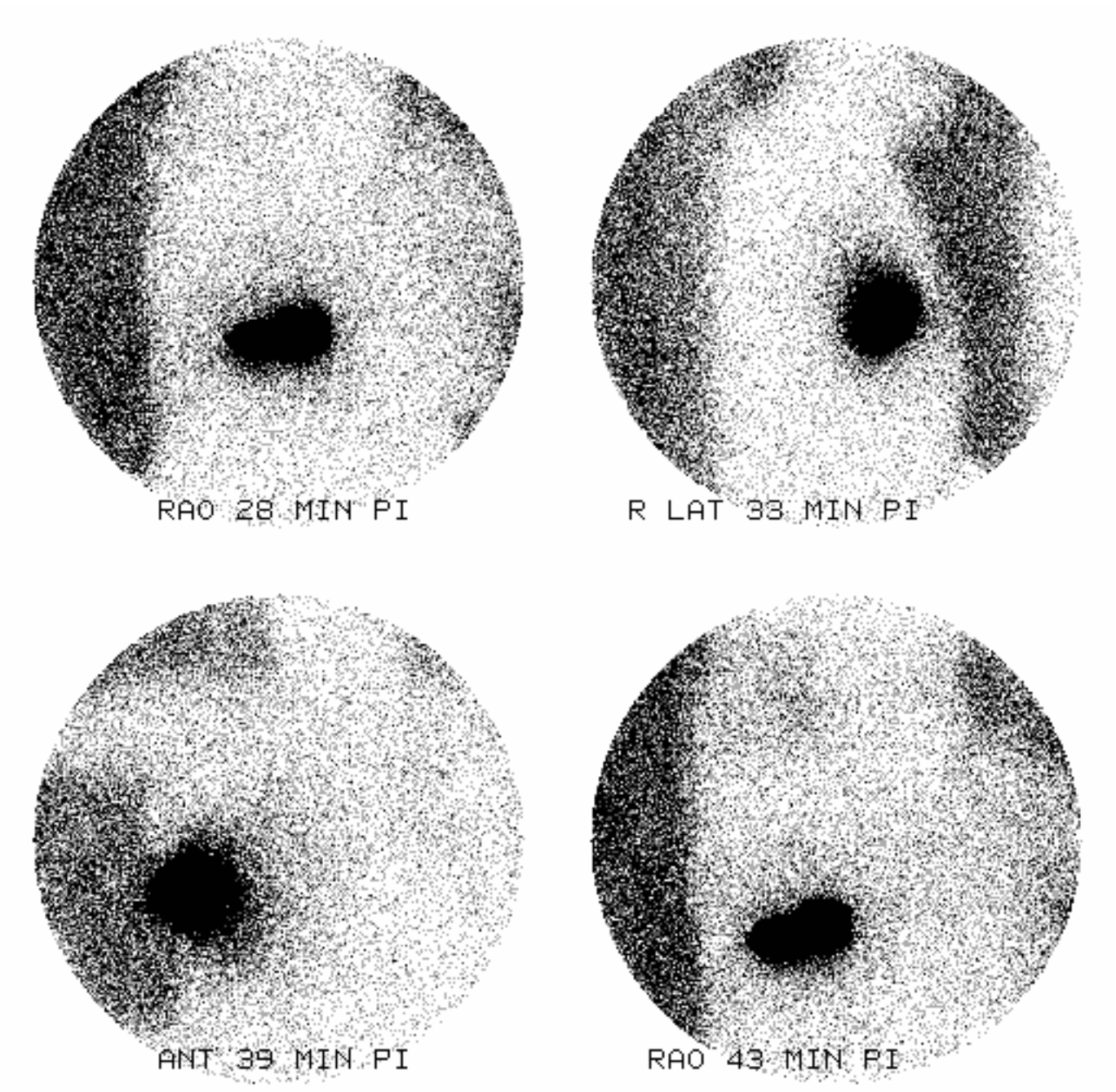
Tissue Resected:

C-Trak

Sample ID	Indicators	Post-ex count	OR img activity	Location
2	Hot/Blue	889	NA	Rt axilla
1	Blue	0	NA	Rt axilla

Preoperative Images




RAO 28 MIN PI
R LAT 33 MIN PI
ANT 39 MIN PI
RAO 43 MIN PI

5x5 Patient: Br11

Date of Study: 03/18/03

Patient Initials: JM

Patient History: Palpable node found in right breast during annual physical, FNA one month later, Ex biopsy three days later (2/25/03)

Sex: F

Age: 77

Location of Tumor/Lesion: Right breast @ 11:00

Surgeon: Styblo

Images/Data of study:

Preop Images: GE 500 by Sandi

OR Images: none

Tissue Resected:

C-Trak

Sample ID	Indicators	Post-ex count	OR img activity	Location
1	Hot/blue		NA	axilla

Comments/Discussion: Node was not very hot. Surgeon did marginal excision around tumor site. Primary mass was excised, hot node was never found, possible subdermal injection spread.

Preoperative Images

LAO 15MIN

LTLAT AX 20MIN

LAO 25MIN

LAO ONSIDE 40MIN

LAO ONSIDE 45MIN

LTLAT 1HR

5x5 Patient: Br12

Date of Study: 07/21/03

Patient Initials: CH

Patient History: Sister died of breast cancer @ 45yo. Six years ago distal left breast cancer. Right breast cancer found by mammography & core biopsy

Sex: F

Age: 56

Location of Tumor/Lesion: Right breast @ 9:00

Surgeon: Styblo

Images/Data of study:

Preop Images: GE 500 by Sandi

OR Images: 5x5 gamma camera

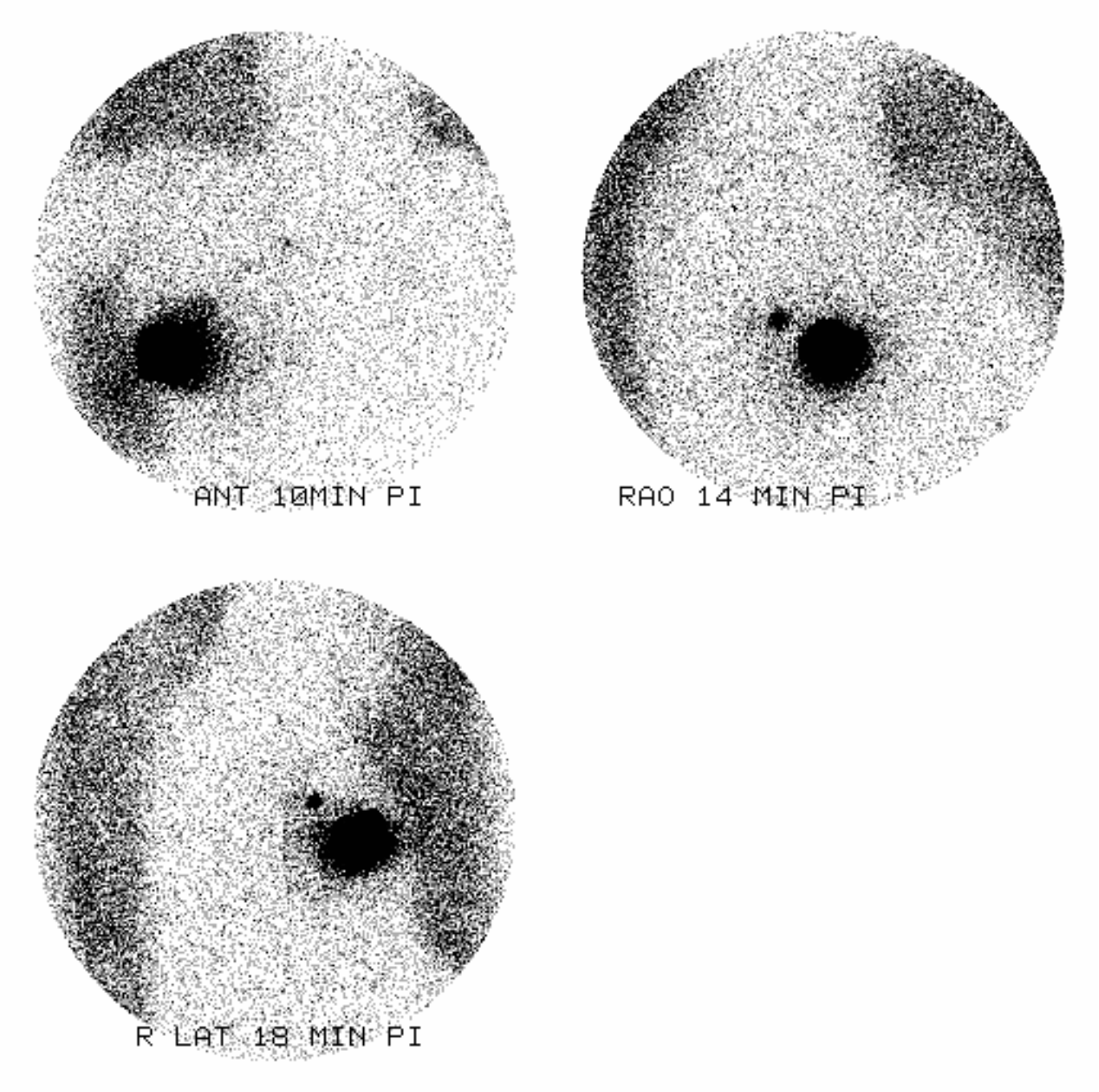
Tissue Resected:

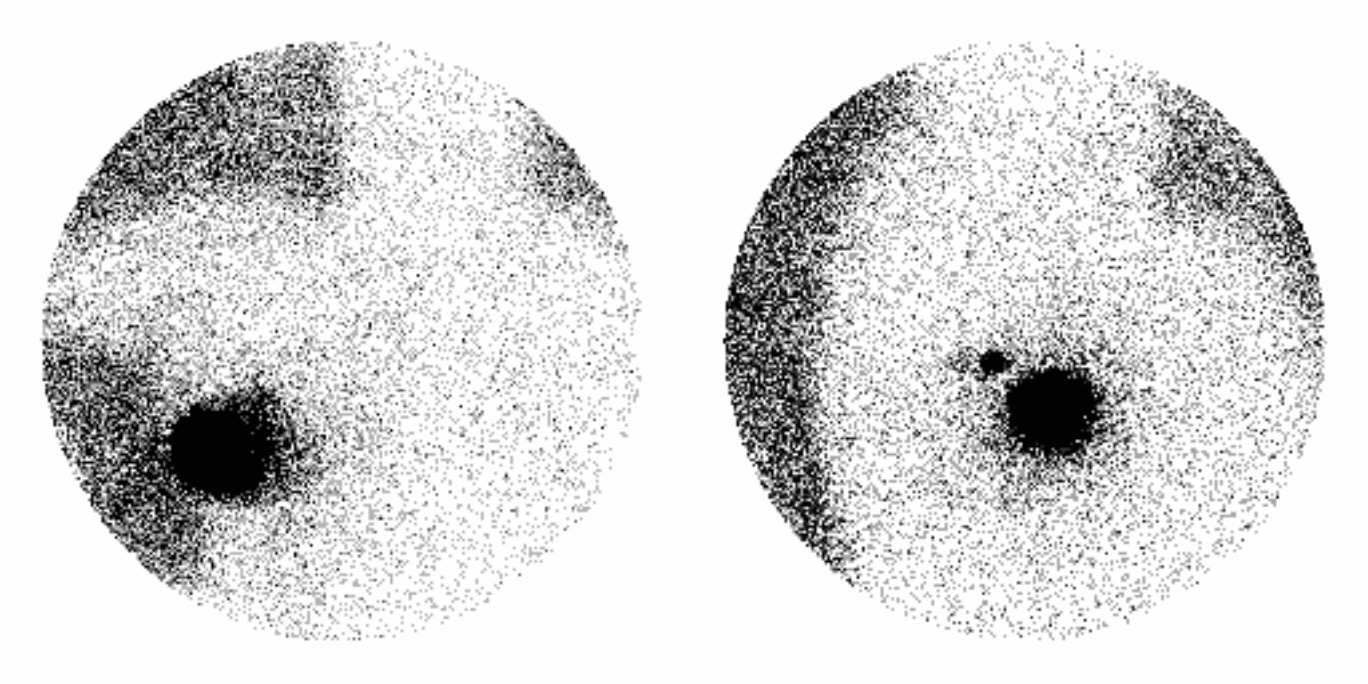
C-Trak

Sample ID	Indicators	Post-ex count	OR img activity	Location
1	Hot/Blue	7436	1317	axilla

BR12

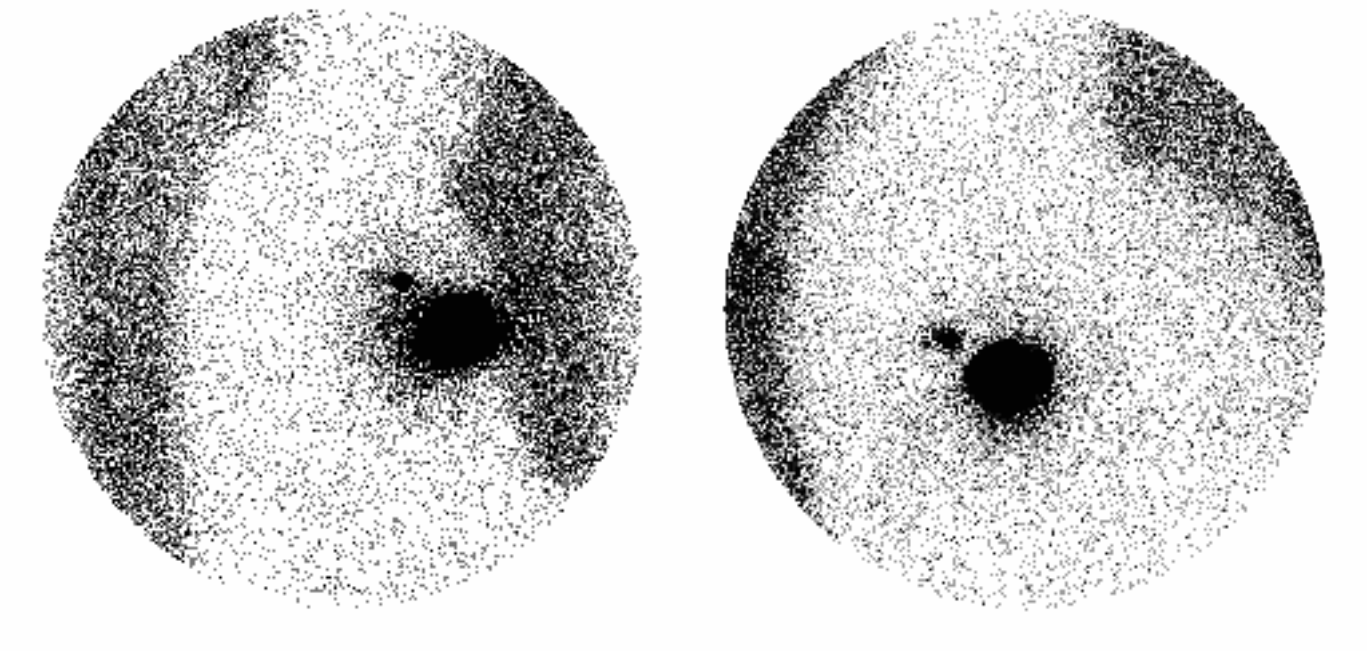
Preoperative Images





ANT 22MIN

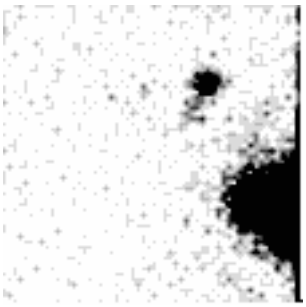
RAO 26MIN



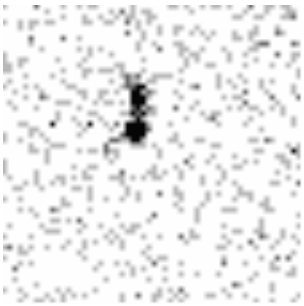
R LAT 31MIN

RAO 44MIN

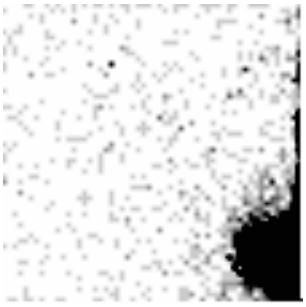
OR Images



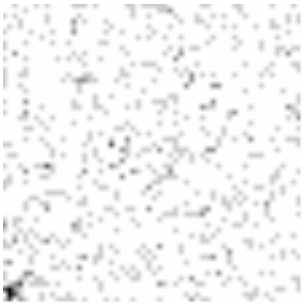
TIFF name: pre-excision Interfile name: BR12
Image duration: 180 sec Start time: 13:49:57



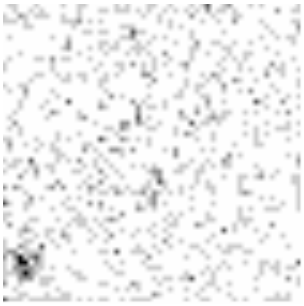
TIFF name: excised node Interfile name: BR12
Image duration: 180 sec Start time: 14:02:19



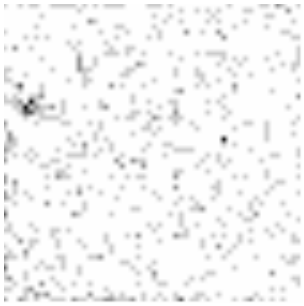
TIFF name: postexcision Interfile name: BR12
Image duration: 180 sec Start time: 14:06:42



TIFF name: supraclavicular 1 Interfile name: BR12
Image duration: 180 sec Start time: 14:11:56



TIFF name: supraclavicular2 Interfile name: BR12
Image duration: 300 sec Start time: 14:15:10



TIFF name: supraclavicular3 Interfile name: BR12
Image duration: 180 sec Start time: 14:21:18

5x5 Patient: B13

Date of Study: 07/22/03

Patient Initials: TV

Patient History: Lump found by routine mammography 06/03

Sex: F

Age:

Location of Tumor/Lesion: Left breast @1:00 ≈5mm

Surgeon: Styblo

Images/Data of study:

Preop Images: GE 500 by S. Grant

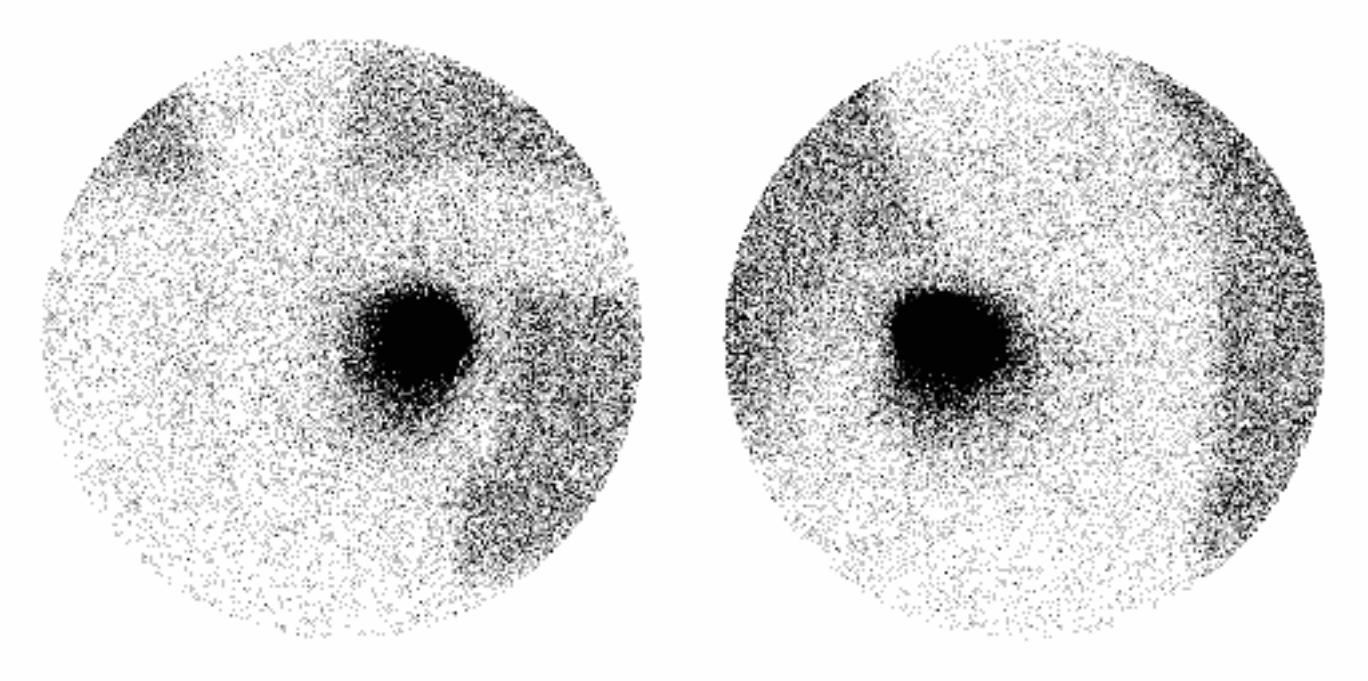
OR Images: 5x5 gamma camera

Tissue Resected:

C-Trak

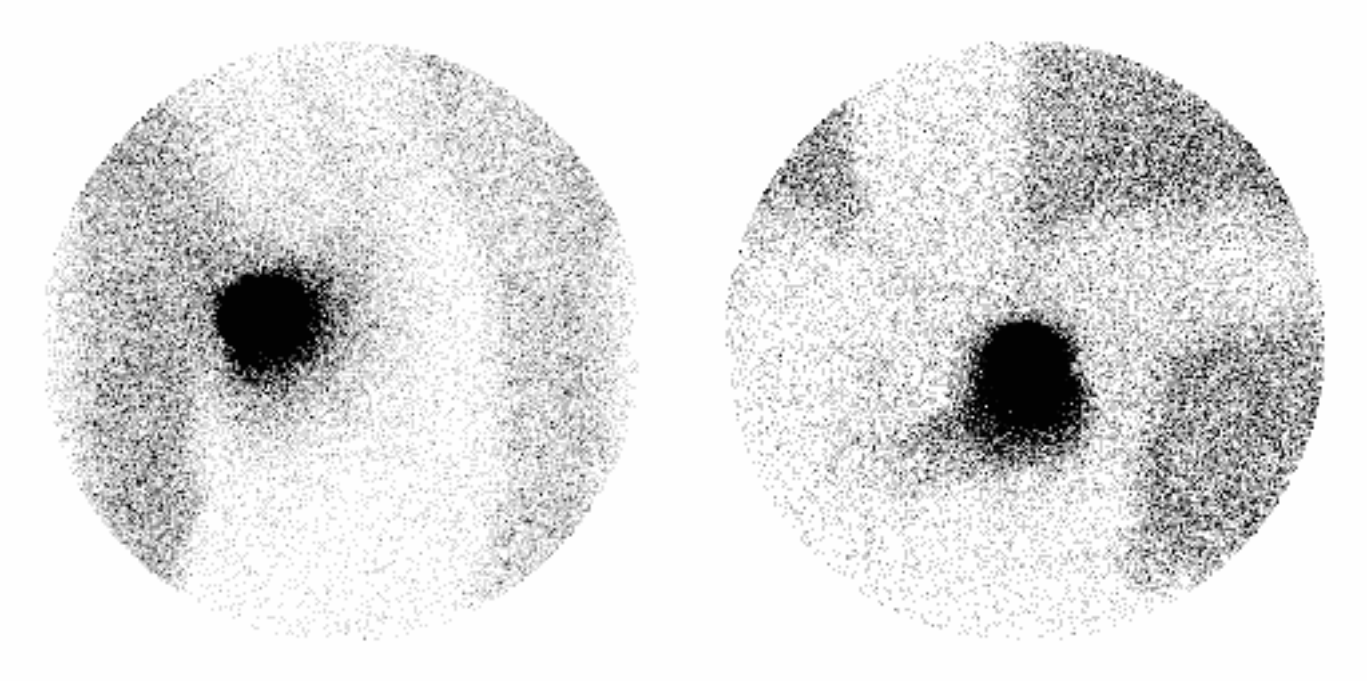
Sample ID	Indicators	Post-ex count	OR img activity	Location
1	Hot	1104	149	axilla

Preoperative Images



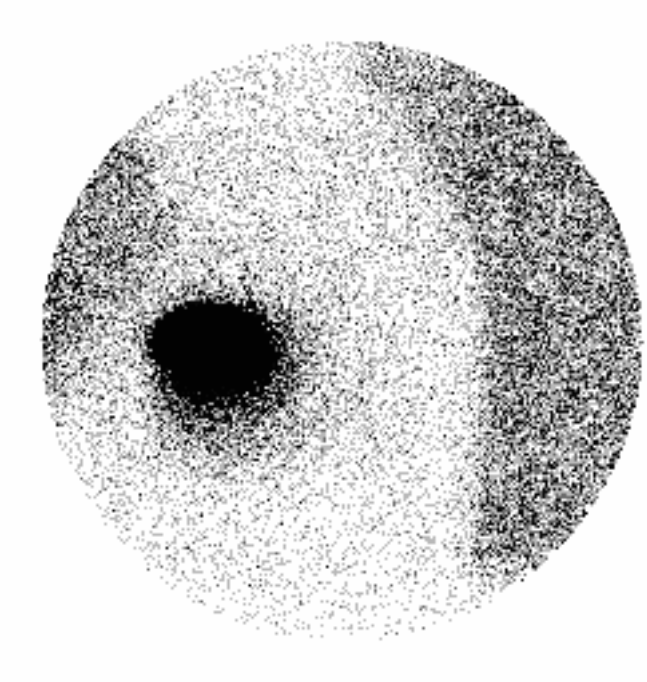
ANT 11MIN

LAO 16MIN

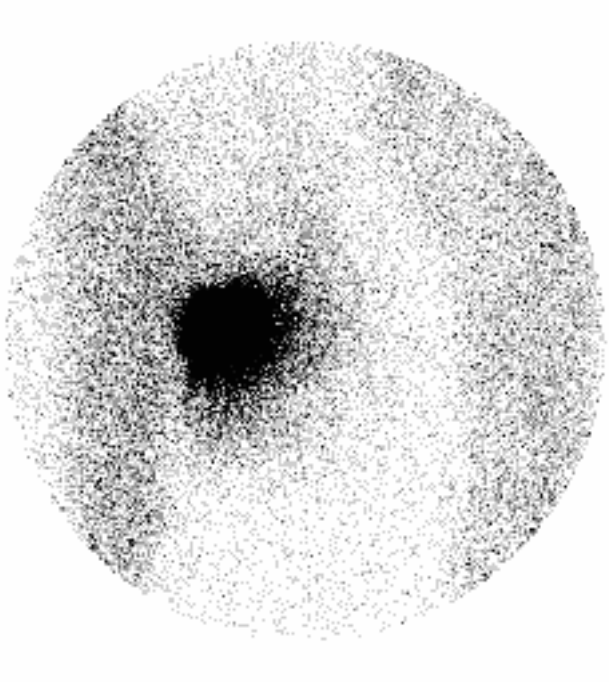


L LAT 20MIN

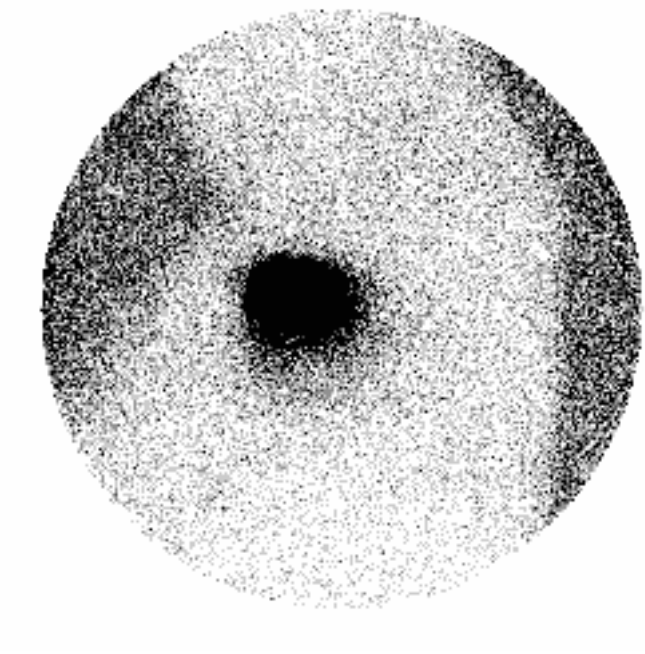
ANT Held 24MIN



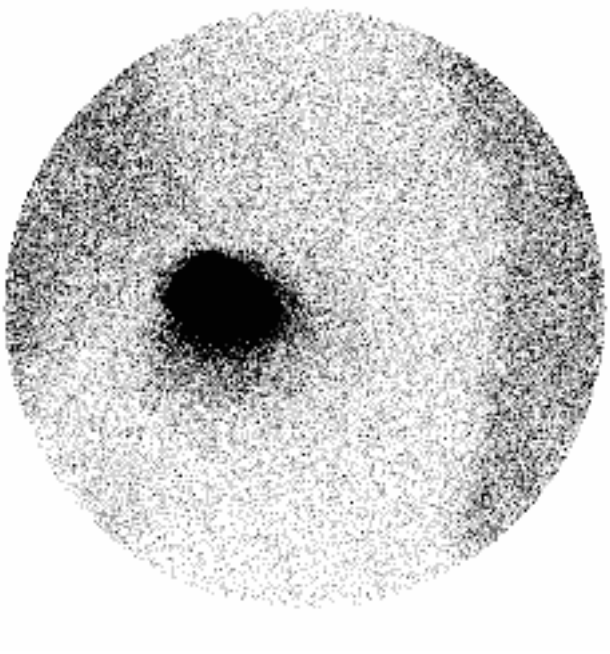
LAO 28MIN



L LAT 35MIN

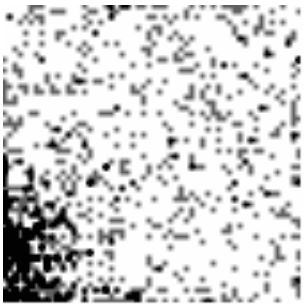


LAO 40MIN

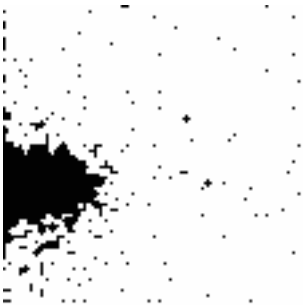


LAO 48MIN

OR Images

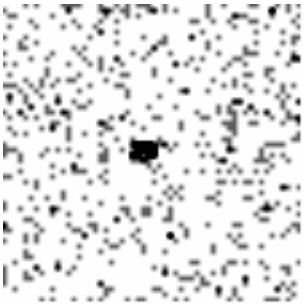


TIFF name: preincision Interfile name: BR13
Image duration: 180 sec Start time: 11:42:26



TIFF name: pre-excision Interfile name: BR13
Image duration: 180 sec Start time: 11:52:59

After the cut was made, but before mass was excised



TIFF name: excised node Interfile name: BR13
Image duration: 180 sec Start time: 11:59:47

TIFF name: post-excision Interfile name: BR13
Image duration: 130 sec Start time: 11:52:59

5x5 Patient: Br14

Date of Study: 08/19/03

Patient Initials: PM

Patient History: Previous right breast tumor. Core biopsy left breast, nonpalpable

Sex: F

Age: 59

Location of Tumor/Lesion: Left breast @6:00 ≈1 cm

Surgeon: Styblo

Images/Data of study:

Preop Images: GE 500 by S. Grant

OR Images: 5x5 gamma camera

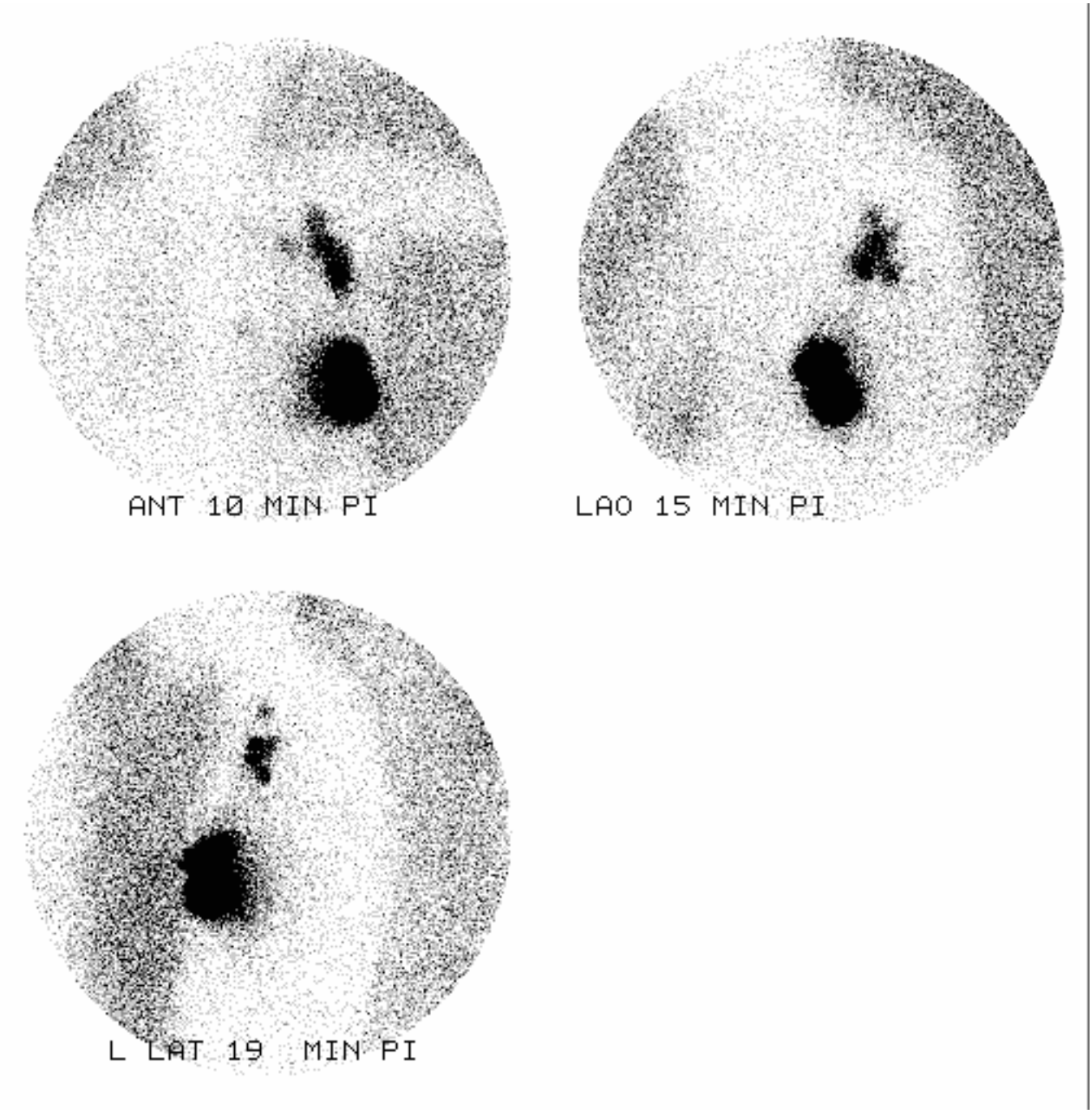
Tissue Resected:

C-Trak

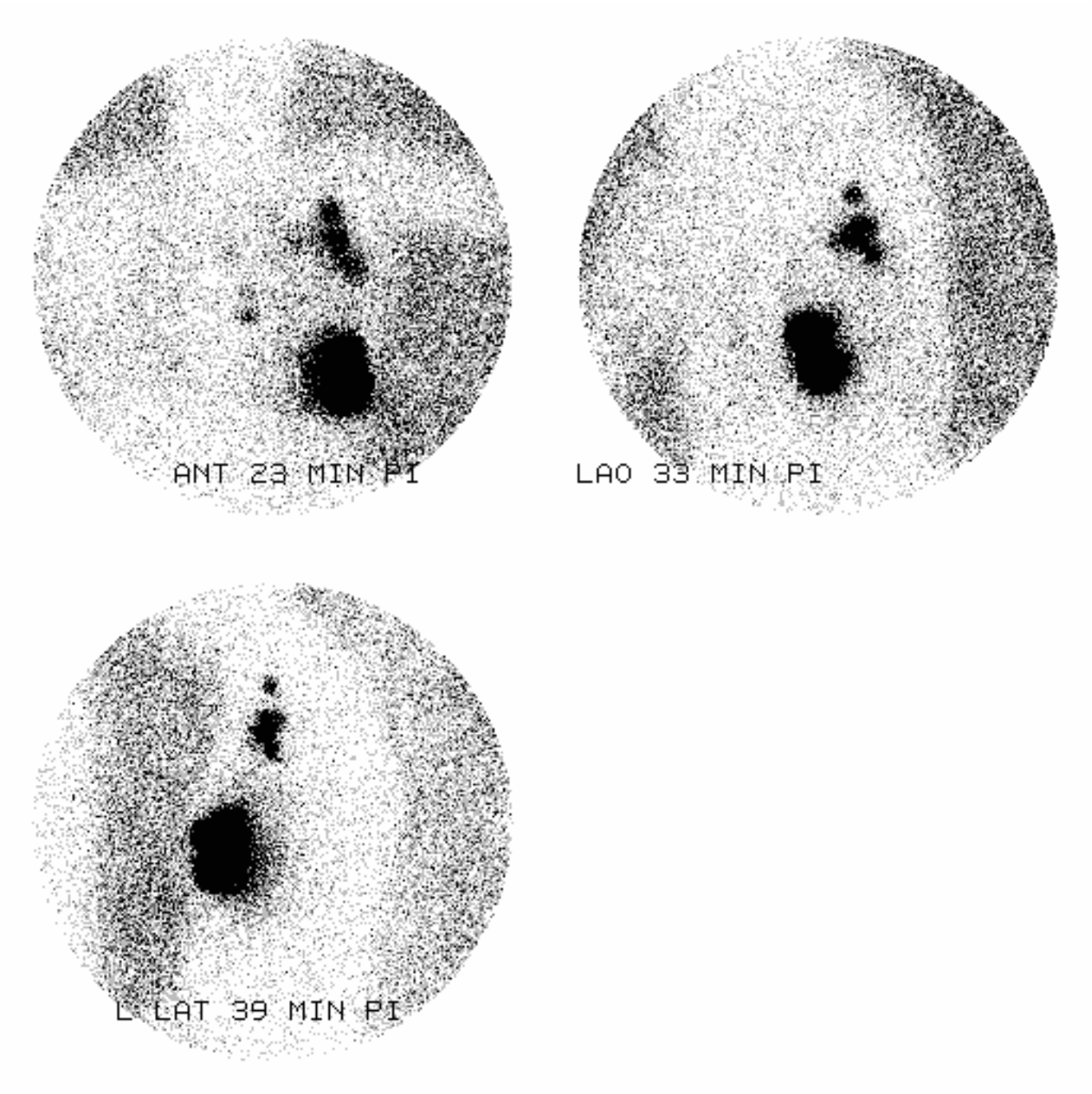
Sample ID	Indicators	Post-ex count	OR img activity	Location
1	Hot/Blue	14632	1107	Lt axilla
1	Hot/Blue	701		Lt axilla
2	Hot/Blue	9971	813	Lt axilla
3	Hot/Blue	3614	77	Lt axilla
4	Hot/Blue	3158	279	Lt axilla

BR14

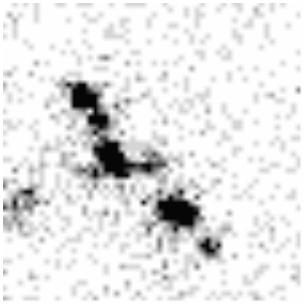
Preoperative Images



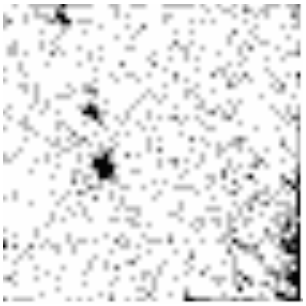
BR14



OR Images

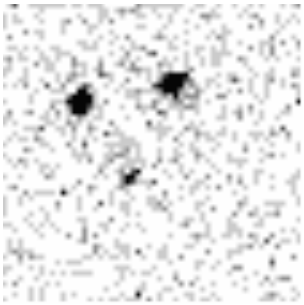


TIFF name: preincision axillary Interfile name: BR14
Image duration: 190 sec Start time: 12:25:15

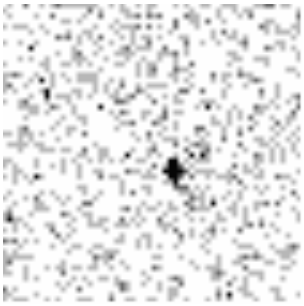


TIFF name: preincision im Interfile name: BR14
Image duration: 181 sec Start time: 12:29:47

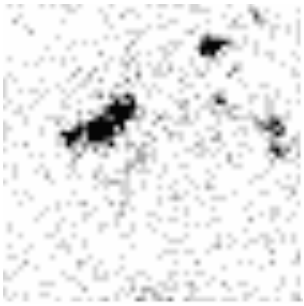
Image of intramammory nodes



TIFF name: excised nodes 1-3 Interfile name: BR14
Image duration: 300 sec Start time: 12:51:28

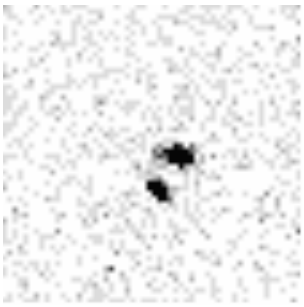


TIFF name: excised node 4 Interfile name: BR14
Image duration: 300 sec Start time: 12:57:16



TIFF name: postexcision axillary Interfile name: BR14
Image duration: 180 sec Start time: 13:05:37

Nodes are still left in axillary



TIFF name: axillary contents dissected Interfile name: BR14
Image duration: 300 sec Start time: 13:49:04

Masses that were hot and blue, not necessarily sentinel

5x5 Patient: Br15

Date of Study: 08/20/03

Patient Initials: HP

Patient History: Nonpalpable

Sex: F

Age: 53

Location of Tumor/Lesion: Right breast behind nipple ≈4x6mm

Surgeon: Styblo

Images/Data of study:

Preop Images: GE 500 by S. Grant

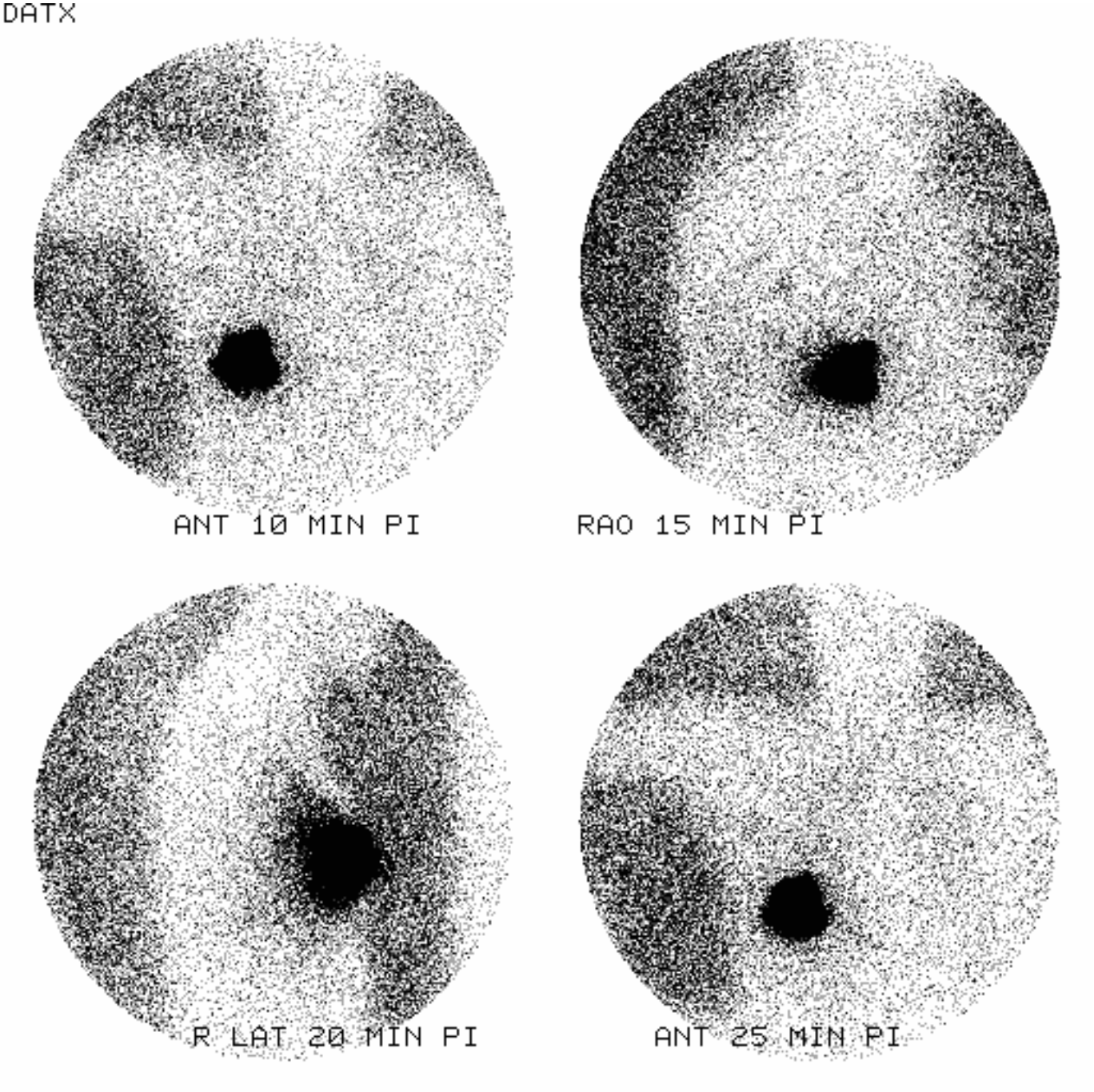
OR Images: 5x5 gamma camera

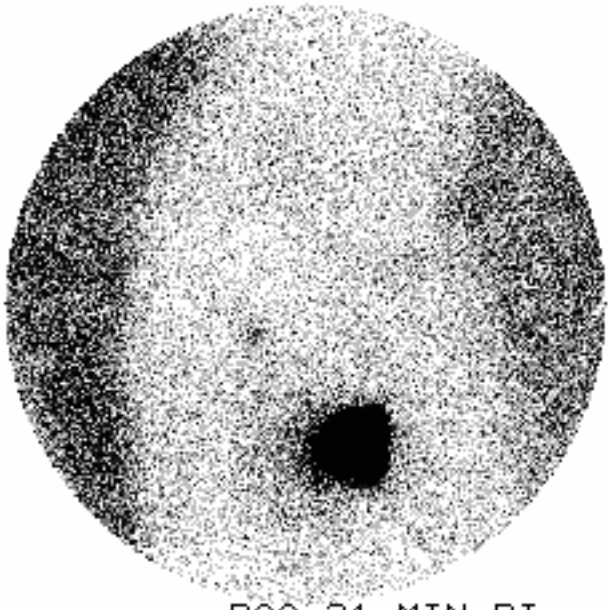
Tissue Resected:

C-Trak

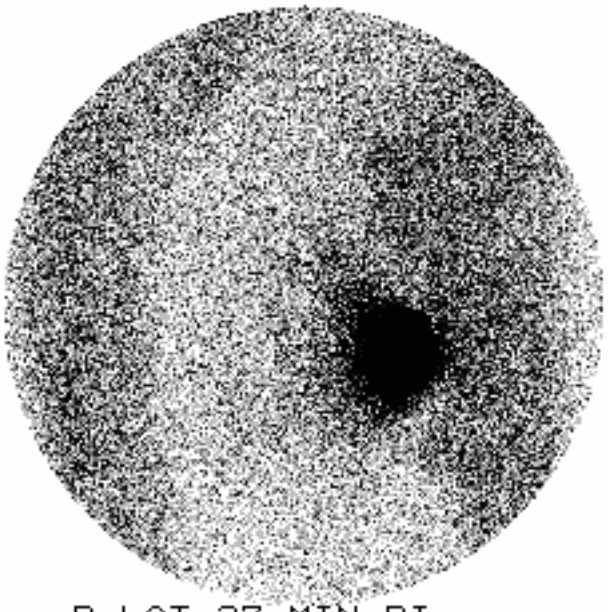
Sample ID	Indicators	Post-ex count	OR img activity	Location
1	Hot	1095	182	axillary
2	Hot	277	35	axillary

Preoperative Images



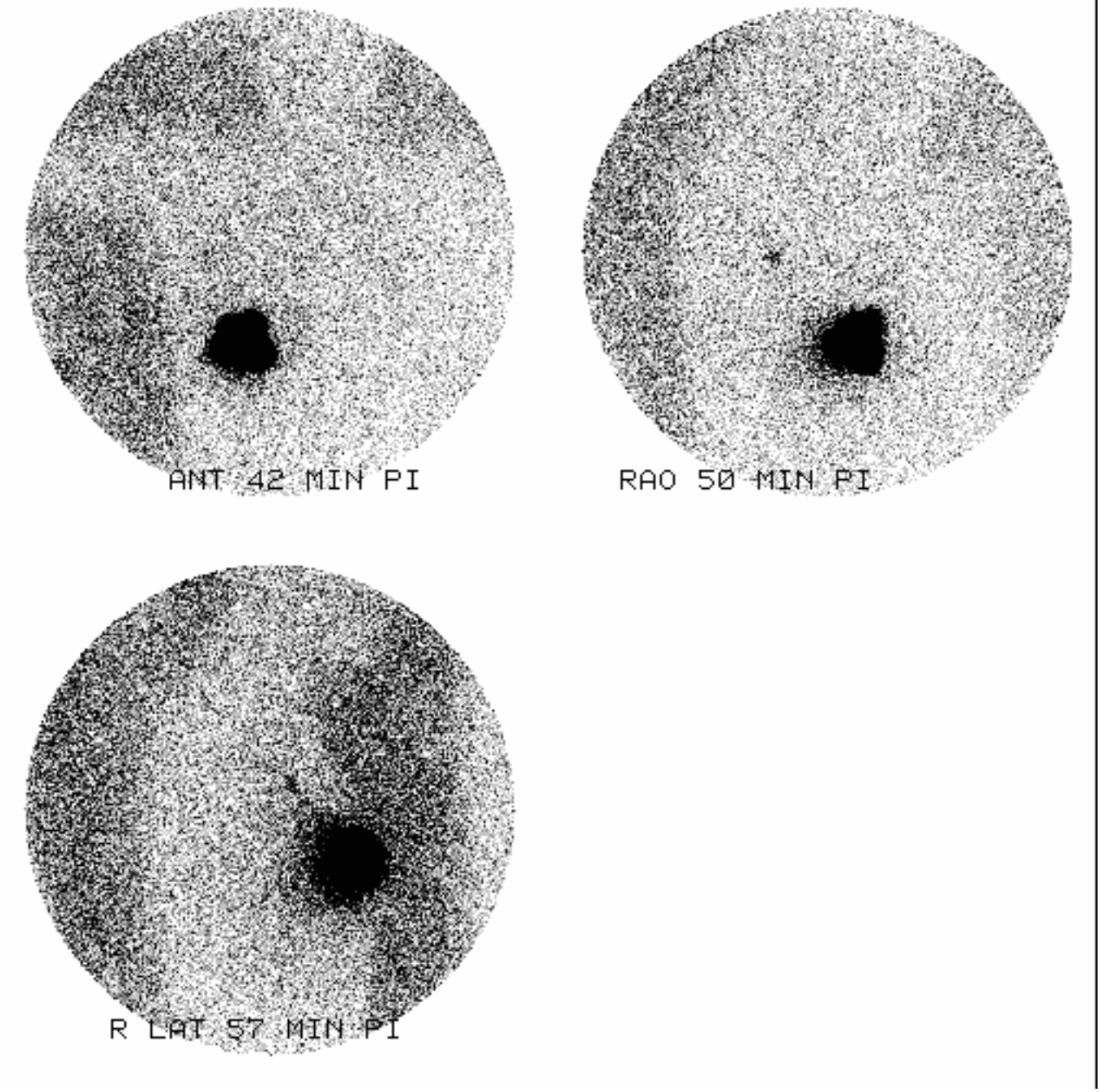


RAO 31 MIN PI

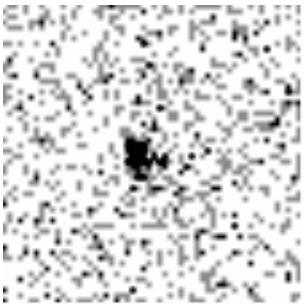


R LAT 37 MIN PI

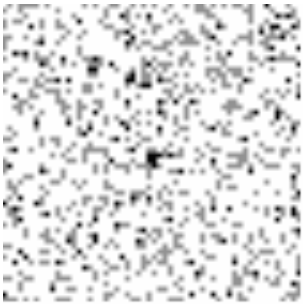
BR15



OR Images



TIFF name: excised node 1 Interfile name: BR15
Image duration: 300 sec Start time: 15:38:06



TIFF name: excised node 2 Interfile name: BR15
Image duration: 300 sec Start time: 15:44:01

BR16

5x5 Patient: Br16

Date of Study: 09/15/03

Patient Initials: VN

Patient History: Palpable mass, sore to the touch

Sex: F

Age: 46

Location of Tumor/Lesion: Right breast @10:00 ≈2cm

Surgeon: Styblo

Images/Data of study:

Preop Images: GE 500 by S. Grant

OR Images: 5x5 gamma camera

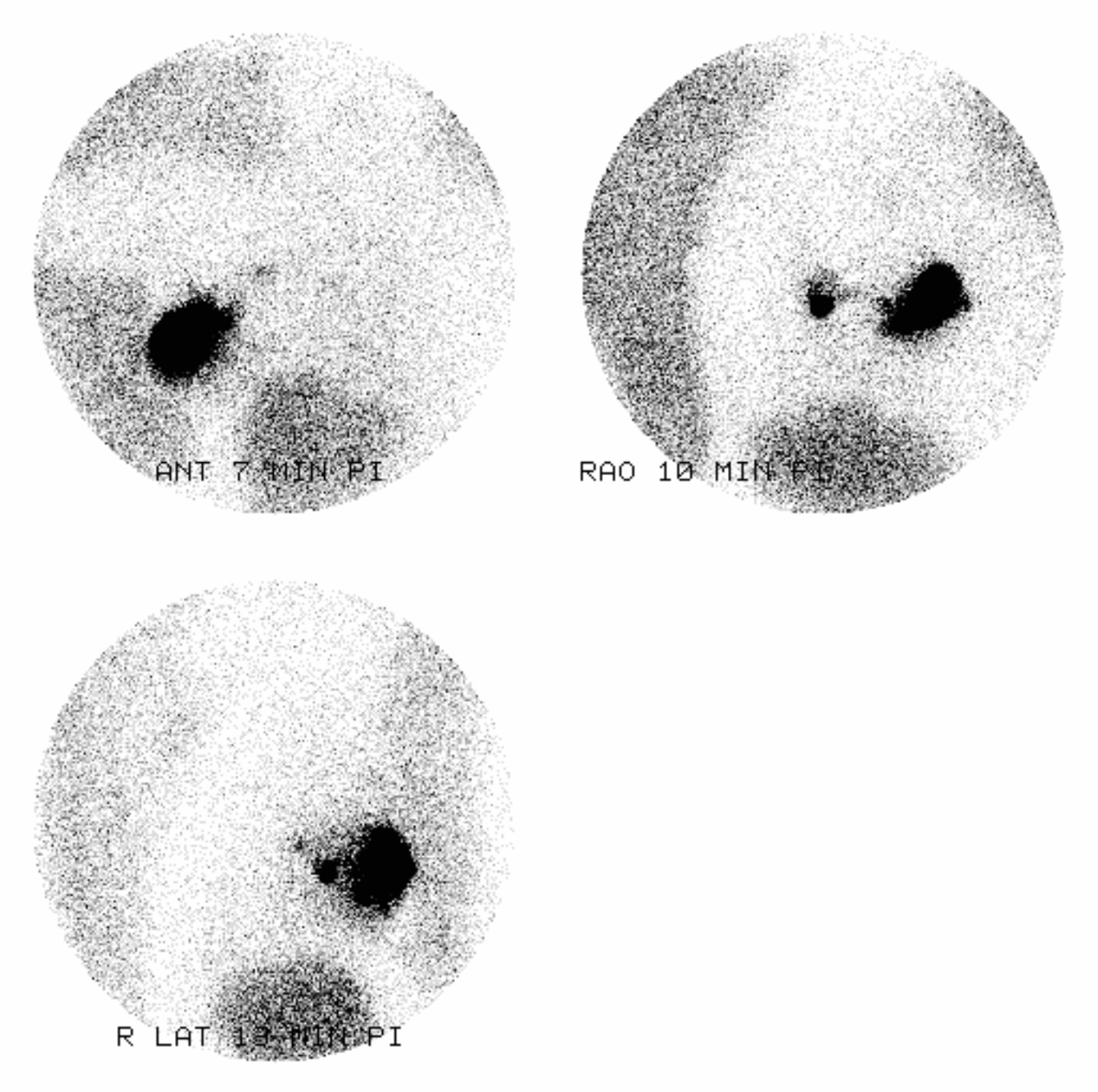
Tissue Resected:

C-Trak

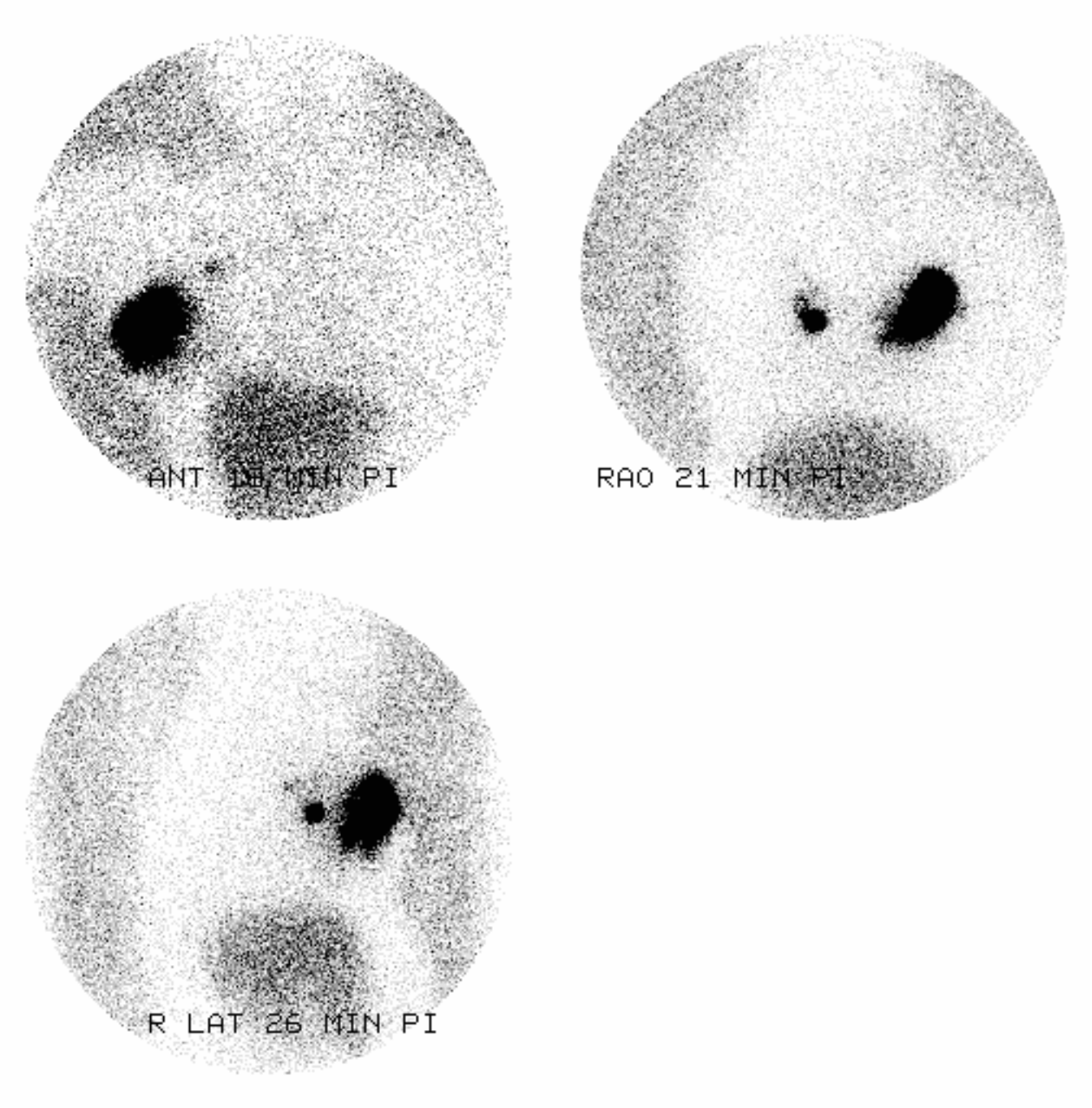
Sample ID	Indicators	Post-ex count	OR img activity	Location
1	Hot/Blue	22291	6496	axilla
2	Hot/Blue	1449	595	axilla

Comments/Discussion: Sandi said there were a total of 6 nodes with in the 3masses and Bob said there were 5 nodes

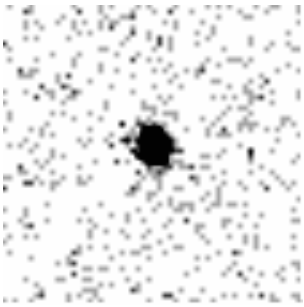
Preoperative Images



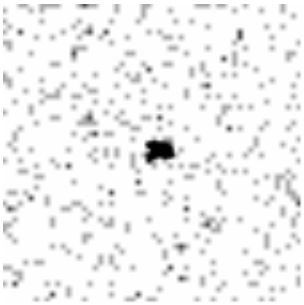
BR16



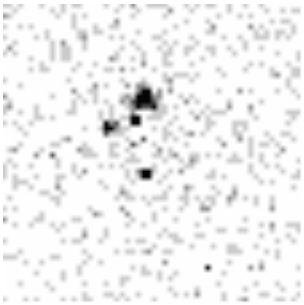
OR Images



TIFF name: excised node 1 Interfile name: BR16
Image duration: 148 sec Start time: 14:14:41



TIFF name: excised node 2 Interfile name: BR16
Image duration: 120 sec Start time: 14:20:23



TIFF name: right axillary content Interfile name: BR16
Image duration: 180 sec Start time: 14:27:00

5x5 Patient: Br17

Date of Study: 09/15/03

Patient Initials: HN

Patient History: Maternal aunt had breast cancer

Sex: F

Age: 41

Location of Tumor/Lesion: Right breast @12:30 ≈1cm

Surgeon: Styblo

Images/Data of study:

Preop Images: GE 500 by S. Grant

OR Images: 5x5 gamma camera

Tissue Resected:

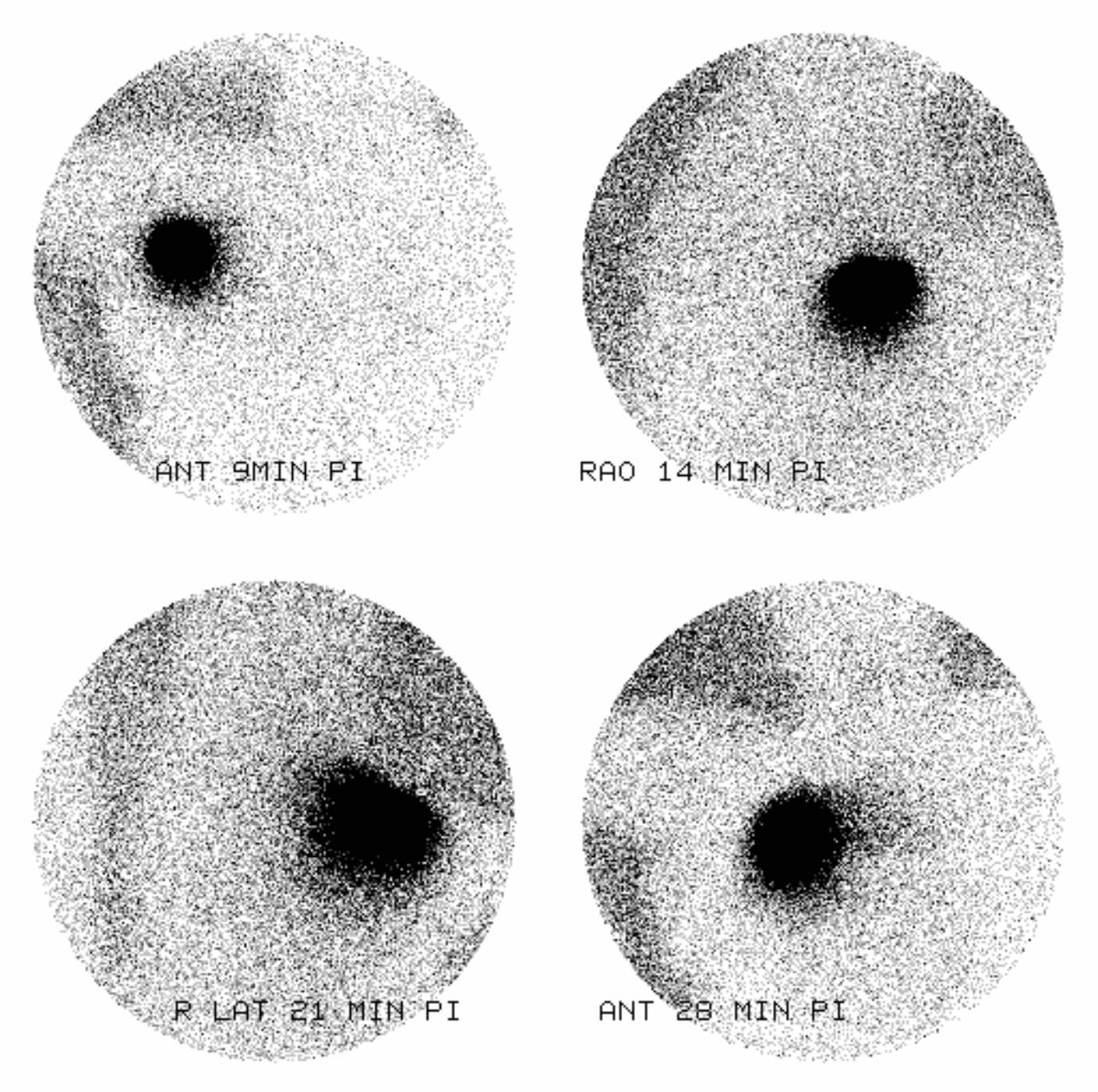
C-Trak

Sample ID	Indicators	Post-ex count	OR img activity	Location
1	Hot/Blue	90	47	axilla

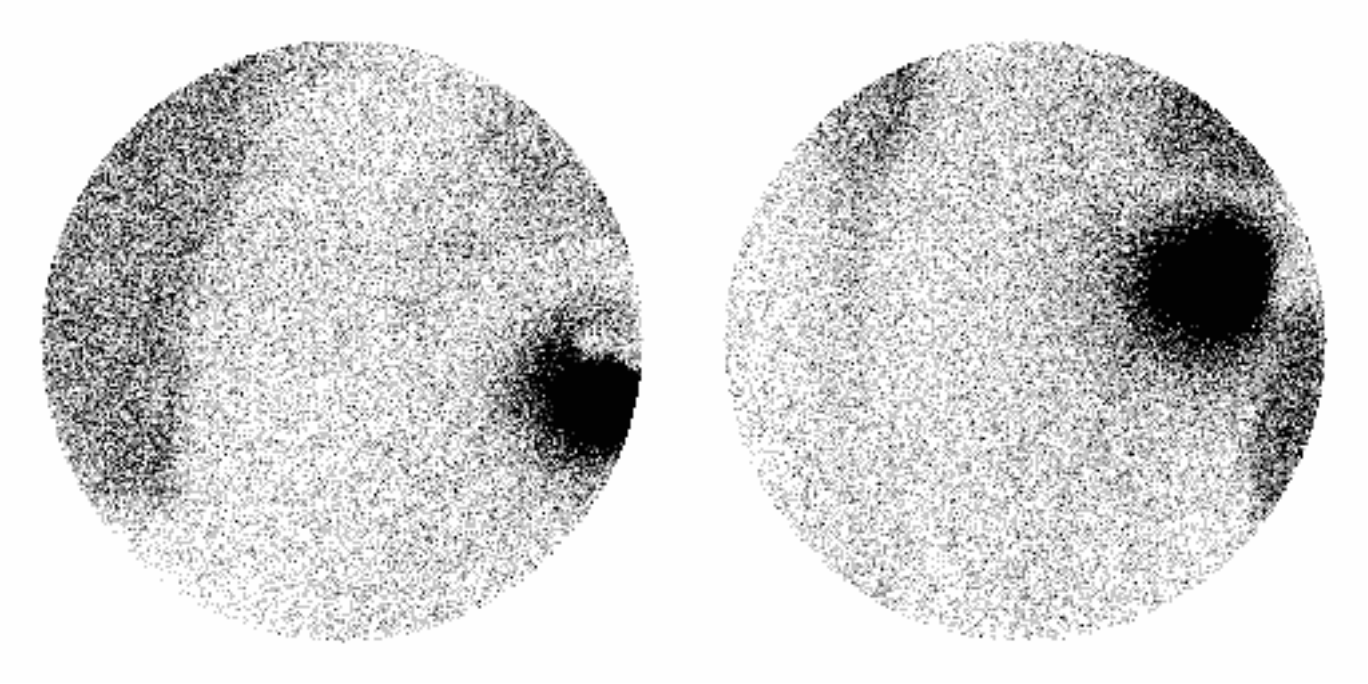
Comments/Discussion: A mass was moved prior to sentinel node, it was blue but had no counts. Surgeon did not send up to frozen section. Case hard, large breast

BR17

Preoperative Images

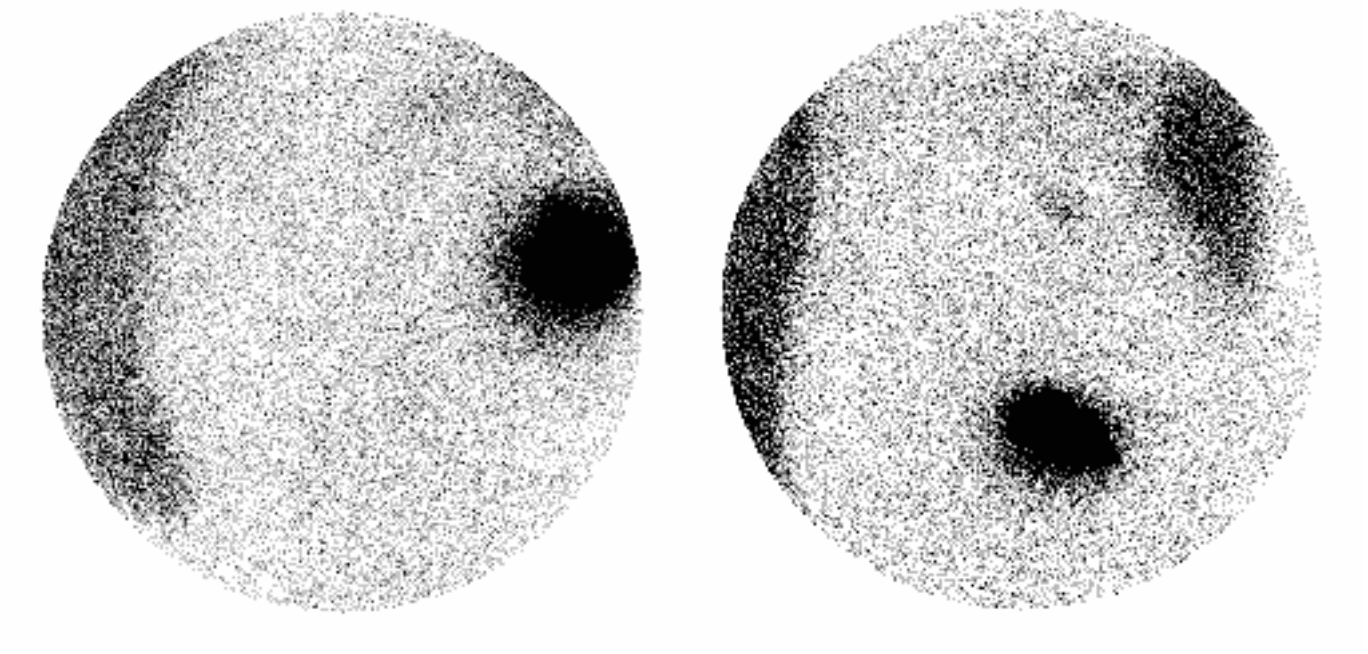


BR17



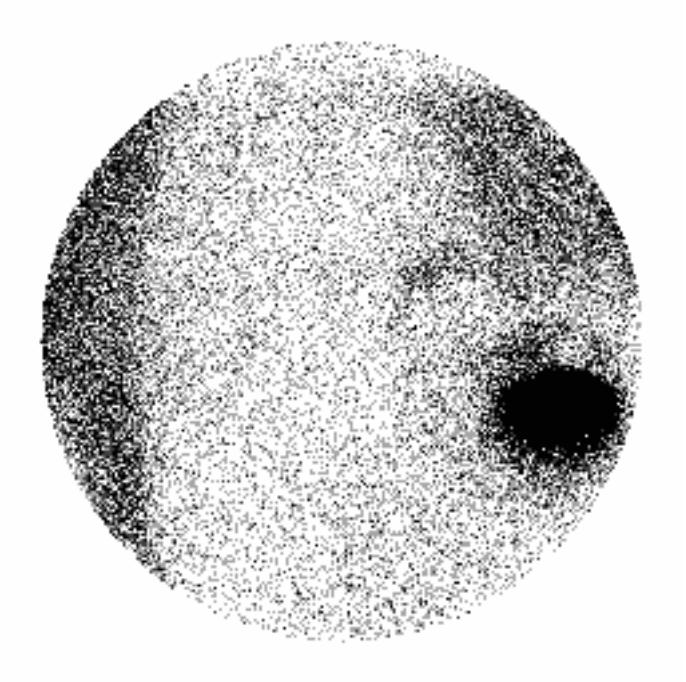
RAO 39MIN

R LAT 47MIN



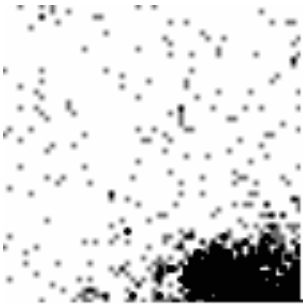
RAO 59MIN

RAO 74MIN



RAO 130MIN

OR Images



TIFF name: anterior preincision Interfile name: BR17
Image duration: 300sec Start time: 15:12:13

TIFF name: mass 1 removed Interfile name: BR17
Image duration: 239 sec Start time: 15:41:47

There were no counts for the first mass removed in the OR

TIFF name: mass 2 removed Interfile name: BR17
Image duration: 300 sec Start time: 15:46:26

The second mass had very little counts in OR

BR18

5x5 Patient: Br18

Date of Study: 09/16/03

Patient Initials: SB

Patient History: Core biopsy, Mother was a study patient 5 yrs ago

Sex: F

Age: 43

Location of Tumor/Lesion: Right breast @6

Surgeon: Styblo

Images/Data of study:

Preop Images: GE 500 by S. Grant

OR Images: 5x5 gamma camera

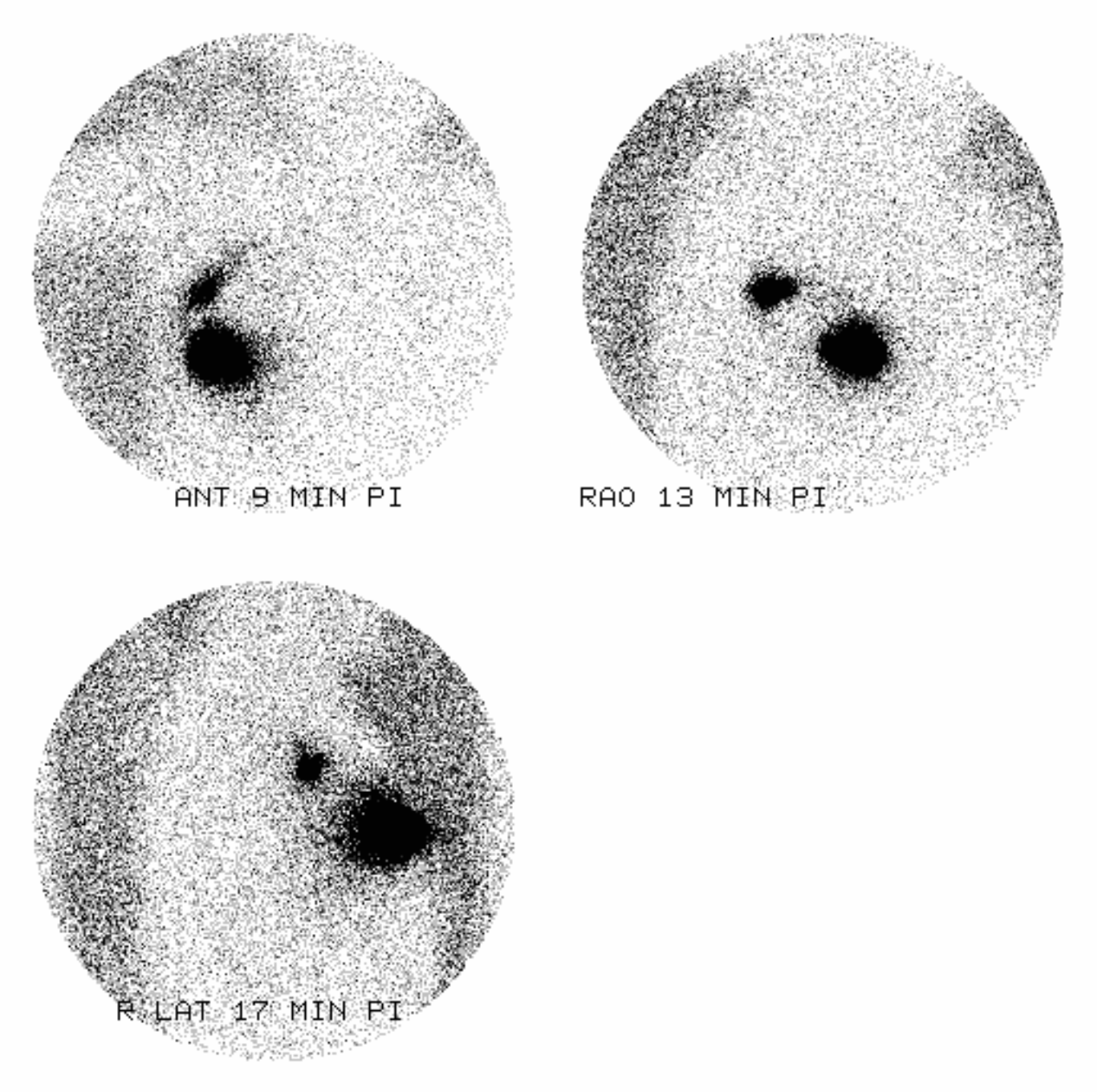
Tissue Resected:

C-Trak

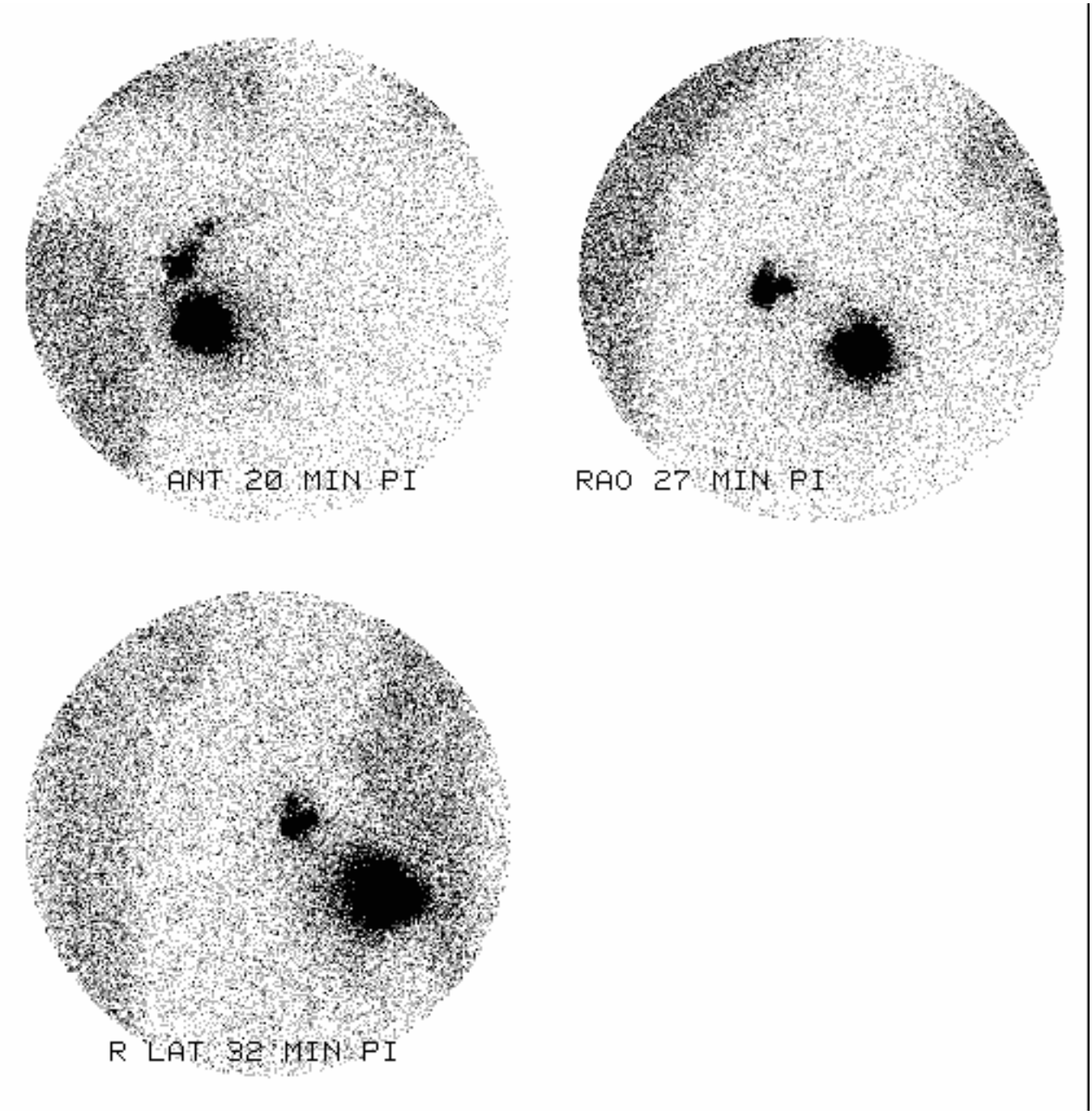
Sample ID	Indicators	Post-ex count	OR img activity	Location
1	Hot/Blue	17661	4402	axilla
3	Hot/Blue	945	102	axilla
2	Hot/Blue	6387	1760	axilla
4	Hot/Blue	4539	704	axilla

Comments/Discussion: Surgeon probably would not have moved as many nodes using only blue dye. With out images(pre-op images?) Surgeon would not have removed 4th node.

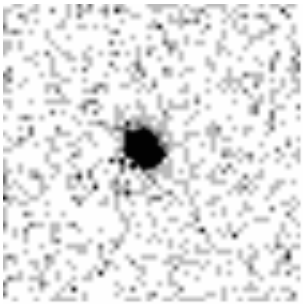
Preoperative Images



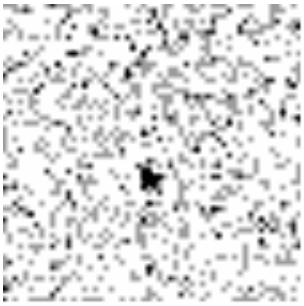
BR18



OR Images

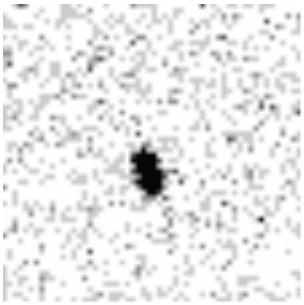


TIFF name: mass 1 Interfile name: BR18
Image duration: 300 sec Start time: 12:05:10



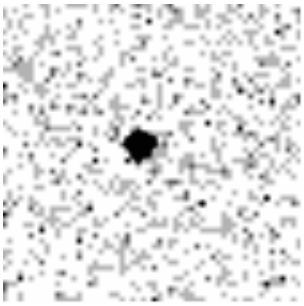
TIFF name: mass 2 Interfile name: BR18
Image duration: 300 sec Start time: 12:11:45

Mass 2 was sent to frozen section as SN #3



TIFF name: mass 3 Interfile name: BR18
Image duration: 300 sec Start time: 12:19:04

Mass 3 was sent to frozen section as SN #2



TIFF name: mass 4 Interfile name: BR18
Image duration: 300 sec Start time: 12:26:15

5x5 Patient: Br19

Date of Study: 11/18/03

Patient Initials: TW

Patient History: Mother had breast cancer at the age of 58. Palpable node, FNA

Sex: F

Age: 42

Location of Tumor/Lesion: Right breast @11:00 ≈1.3x1.2x1.1cm

Surgeon: Styblo

Images/Data of study:

Preop Images: GE 500 by S. Grant

OR Images: 5x5 gamma camera

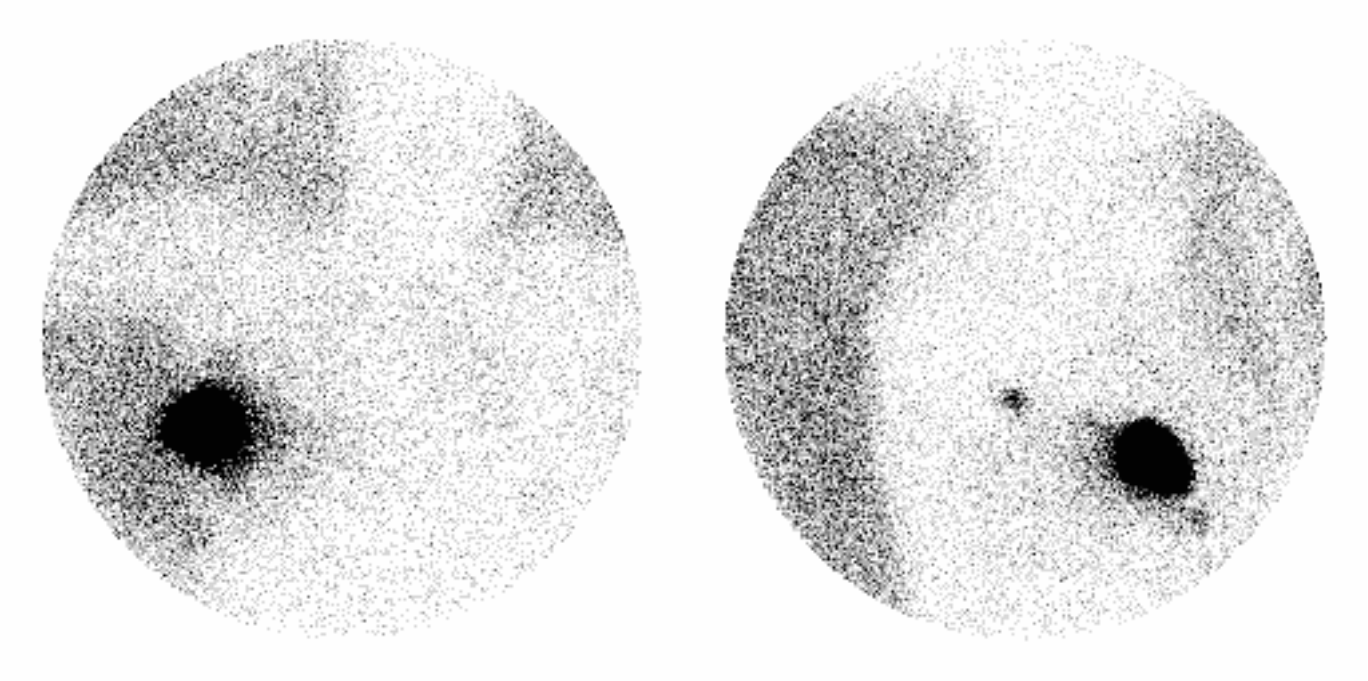
Tissue Resected:

C-Trak

Sample ID	Indicators	Post-ex count	OR img activity	Location
1	Hot/Blue	18204	2949	axilla
2	Hot	1917	177	axilla
3	Hot	3318	279	axilla

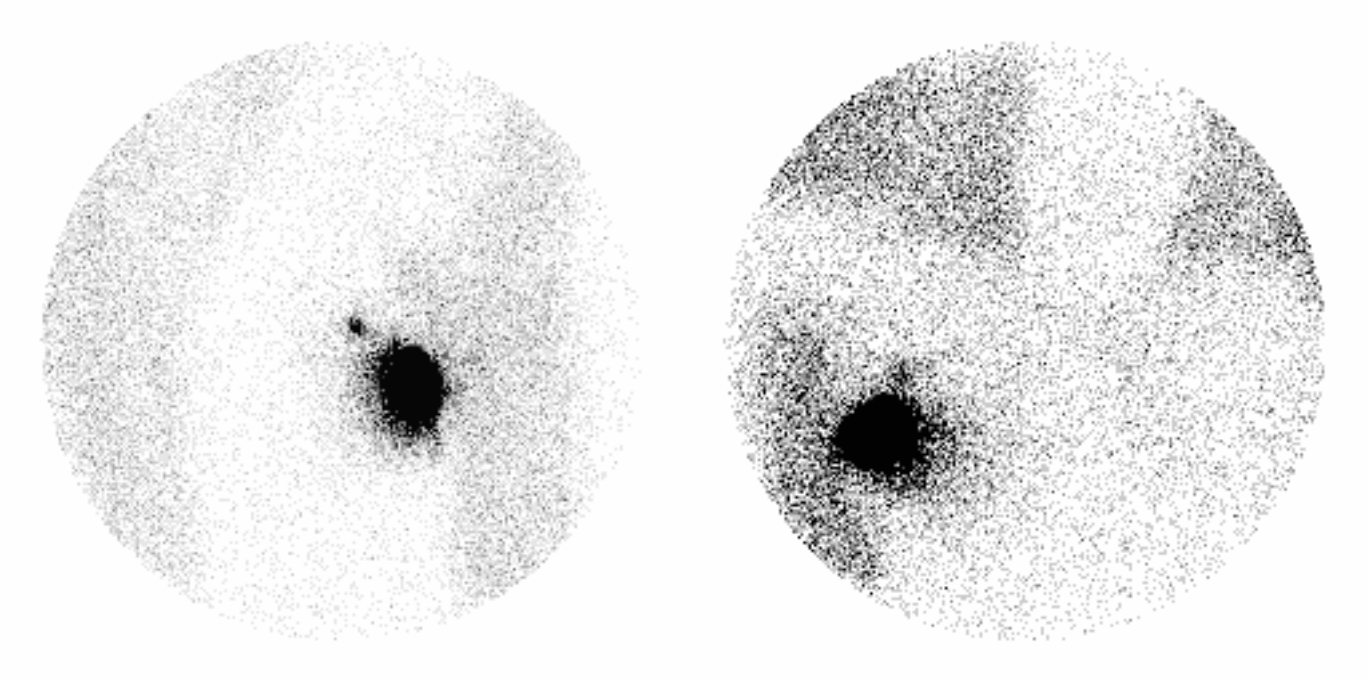
Comments/Discussion: Mass #3 was not sent up for frozen section. Surgeon noted the camera was helpful confirming post excision.

Preoperative Images



ANT 7MIN

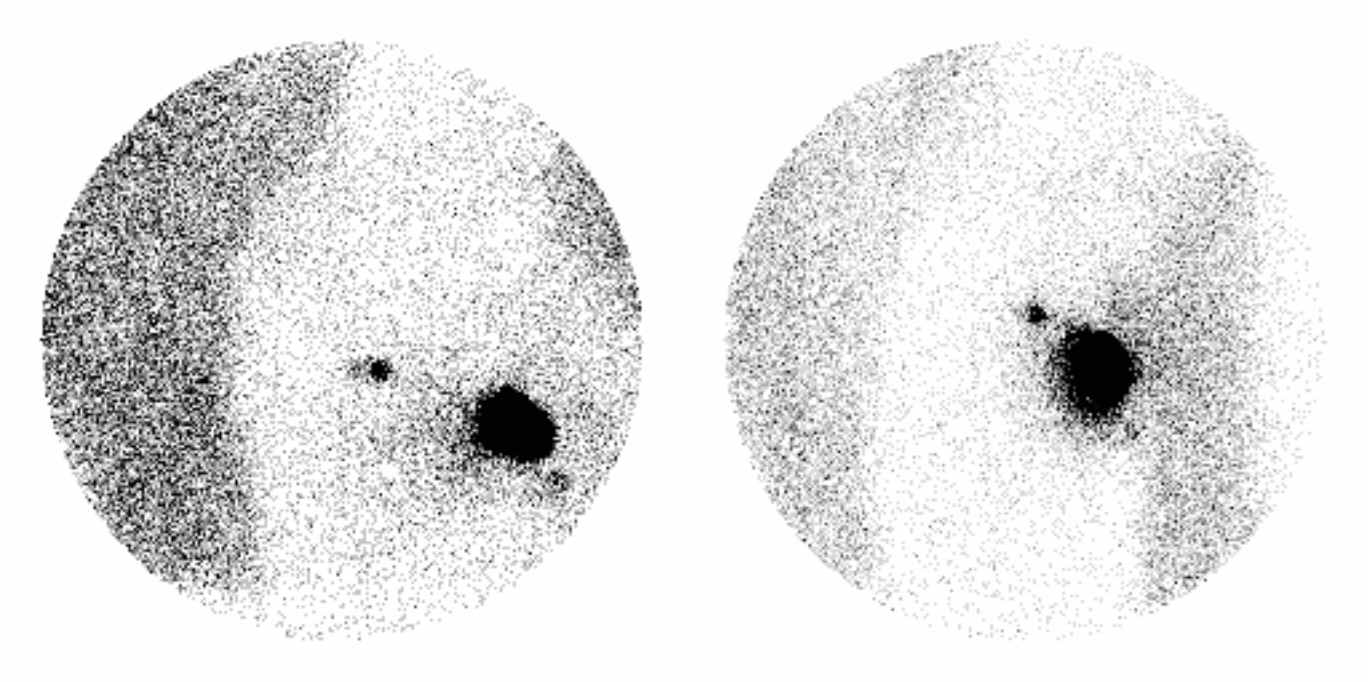
RAO 11MIN



R LAT 15MIN

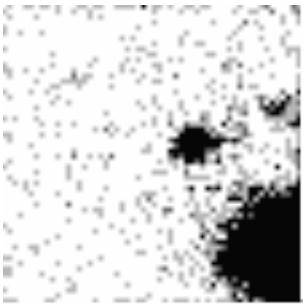
ANT 19MIN

BR19

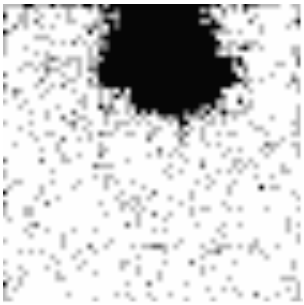


RAO 25MIN **R LAT 32MIN**

OR Images

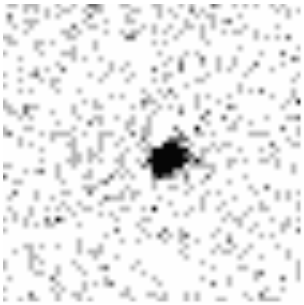


TIFF name: preincision Interfile name: BR19
Image duration: 120 sec Start time: 12:33:48



TIFF name: im preincision Interfile name: BR19
Image duration: 124 sec Start time: 12:36:37

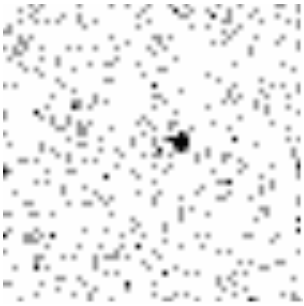
Image of intramammery area



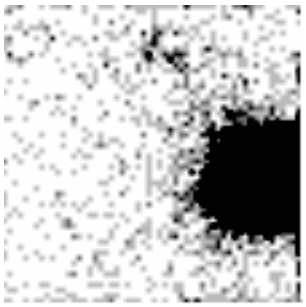
TIFF name: mass 1 Interfile name: BR19
Image duration: 180sec Start time: 12:51:01

TIFF name: mass 2 Interfile name: BR19
Image duration: 190 sec Start time: 12:59:21

BR19



TIFF name: mass 3 Interfile name: BR19
Image duration: 120sec Start time: 13:06:08



TIFF name: post excision Interfile name: BR19
Image duration: 180sec Start time: 13:09:24

5x5 Patient: Br20

Date of Study: 01/28/04

Patient Initials: MW

Patient History: NS

Sex: F

Age: 67

Location of Tumor/Lesion: left breast @3:00 ≈1cm

Surgeon:

Images/Data of study:

Preop Images: GE 500 by S. Grant

OR Images: 5x5 gamma camera

Tissue Resected:

C-Trak

Sample ID	Indicators	Post-ex count	OR img activity	Location
1	Hot	3882	676	axilla

Comments/Discussion: The sample was possibly two nodes

Preoperative Images

LAO 15MIN

LTLAT AX 20MIN

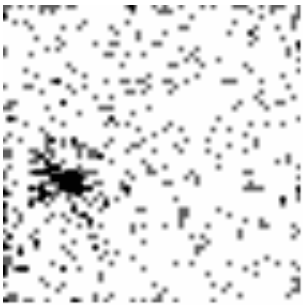
LAO 25MIN

LAO ONSIDE 40MIN

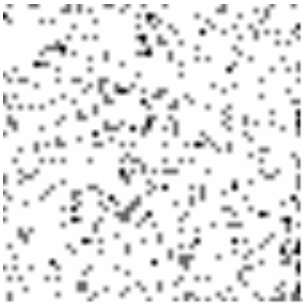
LAO ONSIDE 45MIN

LTLAT 1HR

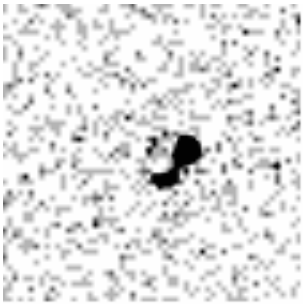
OR Images



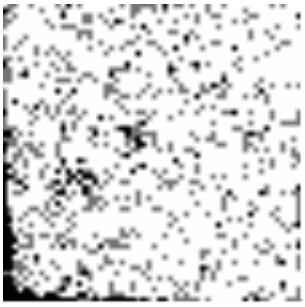
TIFF name: preincision Interfile name: BR20
Image duration: 118sec Start time: 13:06:16



TIFF name: preincision 2 Interfile name: BR20
Image duration: 175 sec Start time: 13:09:38



TIFF name: excised node Interfile name: BR20
Image duration: 300 sec Start time: 13:25:35



TIFF name: postexcision Interfile name: BR20
Image duration: 225 sec Start time: 13:31:53

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